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Seventh Annual Issue

Colorado State Univ, Fort Collins

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Robert S Kerr Environmental Research Lab, Ada, OK

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Research related to the quality of irrigation return flow is being conducted at numerous institutions throughout the western United States. Related work is also underway at other institutions in the United States as well as other portions of the world. Approximately 100 sources of material have been searched for articles pertinent to the Irrigated Crop Production research and development program. These articles describe water quality problems resulting from irrigated agriculture, potential technological solutions for controlling return flows, recent research pertinent to return flow investigations, and literature associated with institutional constraints in irrigation return flow quality control.

The first annual issue of SELECTED IRRIGATION RETURN FLOW QUALITY ABSTRACTS covered publications printed in 1968 and 1969, while the second annual issue lists publications printed in 1970 and 1971, the third annual issue covers calendar years 1972 and 1973, and the fourth, fifth, and sixth annual issues cover literature published in 1974, 1975, and 1976. This annual issue lists publications printed in 1977.

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January 1979

SELECTED IRRIGATION RETURN FLOW QUALITY ABSTRACTS 1977

Seventh Annual Issue

by

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FOREWORD

The Environmental Protection Agency was established to coordinate administration of the major Federal programs designed to protect the quality of our environment.

An important part of the Agency's effort involves the search for information about environmental problems, management techniques and new technologies through which optimum use of the Nation's land and water resources can be assured and the threat pollution poses to the welfare of the American people can be minimized.

EPA's Office of Research and Development conducts this search through a nationwide network of research facilities.

As one of these facilities, the Robert S. Kerr Environmental Research Laboratory is responsible for the management of programs to: (a) investigate the nature, transport, fate and management of pollutants in groundwater; (b) develop and demonstrate methods for treating wastewaters with soil and other natural systems; (c) develop and demonstrate pollution control technologies for irrigation return flows; (d) develop and demonstrate pollution control technologies for animal production wastes; (e) develop and demonstrate technologies to prevent, control or abate pollution from the petroleum refining the petrochemical industries; and (f) develop and demonstrate technologies to manage pollution resulting from combinations of industrial wastewaters or industrial/municipal wastewaters.

This report contributes to the knowledge essential if the EPA is to meet the requirements of environmental laws that it establish and enforce pollution control standards which are reasonable, cost effective and provide adequate protection for the American public.

William C Galegar

William C. Galegar
Director
Robert S. Kerr Environmental
Research Laboratory

PREFACE

The seventh annual issue of SELECTED IRRIGATION RETURN FLOW QUALITY ABSTRACTS has been compiled from approximately 100 sources of material covering calendar year 1977. This compilation has attempted to include technological and institutional articles that would be pertinent to action programs regarding the control of water quality degradation resulting from irrigated agriculture.

The state-of-the-art report, "Characteristics and Pollution Problems of Irrigation Return Flow," prepared by the Utah State University Foundation, contains a bibliography of articles pertinent to Irrigation Return Flow Quality through 1967. The first annual issue of SELECTED IRRIGATION RETURN FLOW QUALITY ABSTRACTS listed publications appearing in calendar years 1968 and 1969, while the second annual issue listed publications appearing in calendar years of 1970 and 1971, the third annual issue contained abstracts of articles and reports published during calendar years 1972 and 1973, and the fourth, fifth, and sixth annual issues contained abstracts of 1974, 1975, and 1976 publications. The seventh annual issue contains 731 abstracts of documents published during calendar year 1977. The abstracts have been placed into sections according to the category and subgroup classifications used by the Water Resources Scientific Information Center (WRSIC) as published in the report, "Water Resources Thesaurus." The abstracts have been forwarded to WRSIC for inclusion in their bi-monthly publication, "Selected Water Resources Abstracts."

ABSTRACT

Research related to the quality of irrigation return flow is being conducted at numerous institutions throughout the western United States. Related work is also underway at other institutions in the United States, as well as other portions of the world. Approximately 100 sources of material have been searched for articles pertinent to the Irrigated Crop Production research and development program. These articles describe water quality problems resulting from irrigated agriculture, potential technological solutions for controlling return flows, recent research pertinent to return flow investigations, and literature associated with institional constraints in irrigation return flow quality control.

The first annual issue of SELECTED IRRIGATION RETURN FLOW QUALITY ABSTRACTS covered publications printed in 1968 and 1969, while the second annual issue lists publications printed in 1970 and 1971, the third annual issue covers calendar years 1972 and 1973, and the fourth, fifth, and sixth annual issues cover literature published in 1974, 1975, and 1976. This annual issue lists publications printed in 1977. This report was submitted in fulfillment of Grant No. R-800426 under the sponsorship of the Office of Research and Development, U.S. Environmental Protection Agency.

Key Words: Fertilizers, Irrigated land, Irrigation Systems, Irrigation water, Nitrates, Phosphates, Return flow, Salinity, Water pollution effects, Water pollution sources, Water quality control.

TABLE OF CONTENTS

Foreword iii
Preface iv
Abstract v
Acknowledgments viii

I WATER CYCLE - Precipitation (Group 02B) 1
II WATER CYCLE - Snow, Ice, and Frost (Group 02C) 2
III WATER CYCLE - Evaporation and Transpiration (Group 02D) 3
IV WATER CYCLE - Streamflow and Runoff (Group 02E) . . . 8
V WATER CYCLE - Groundwater (Group 02F) 11
VI WATER CYCLE - Water in Soils (Group 02G) 30
VII WATER CYCLE - Water and Plants (Group 02I) 92
VIII WATER CYCLE - Erosion and Sedimentation (Group 02J) . 99
IX WATER CYCLE - Chemical Processes (Group 02K) 115
X WATER CYCLE - Estuaries (Group 02L) 117
XI WATER SUPPLY AUGMENTATION AND CONSERVATION - Saline Water Conversion (Group 03A) 118
XII WATER SUPPLY AUGMENTATION AND CONSERVATION - Water Yield Improvement (Group 03B) 119
XIII WATER SUPPLY AUGMENTATION AND CONSERVATION - Use of Water of Impaired Quality (Group 03C) 120
XIV WATER SUPPLY AUGMENTATION AND CONSERVATION - Conservation in Agriculture (Group 03F) 122
XV WATER QUANTITY MANAGEMENT AND CONTROL - Control of Water on the Surface (Group 04A) 163
XVI WATER QUANTITY MANAGEMENT AND CONTROL - Groundwater Management (Group 04B) 177
XVII WATER QUANTITY MANAGEMENT AND CONTROL - Watershed Protection (Group 04D) 183
XVIII WATER QUALITY MANAGEMENT AND PROTECTION - Identification of Pollutants (Group 05A) 186
XIX WATER QUALITY MANAGEMENT AND PROTECTION - Sources and Fate of Pollution (Group 05B) 191
XX WATER QUALITY MANAGEMENT AND PROTECTION - Effects of Pollution (Group 05C) 213
XXI WATER QUALITY MANAGEMENT AND PROTECTION - Waste Treatment Processes (Group 05D) 215
XXII WATER QUALITY MANAGEMENT AND PROTECTION - Ultimate Disposal of Wastes (Group 05E) 219

Preceding page blank

XXVII WATER QUALITY MANAGEMENT AND PROTECTION - Water Quality Control (Group 05G) 220
XXVIII WATER RESOURCES AND PLANNING - Techniques of Planning (Group 06A). 234
XXIX WATER RESOURCES PLANNING - Evaluation Process (Group 06B) 237
XXX WATER RESOURCES PLANNING - Cost Allocation, Cost Sharing, Pricing/Repayment (Group 06C) 238
XXXI WATER RESOURCES PLANNING - Water Demand (Group 06D) . 239
XXXII WATER RESOURCES PLANNING - Water Law and Institutions (Group 06E) 240
XXIII RESOURCES DATA - Data Acquisition (Group 07B) 245
XXV ENGINEERING WORKS - Structures (Group 08A). 258
XXVI ENGINEERING WORKS - Hydraulics (Group 08B). 259
XXXIII ENGINEERING WORKS - Hydraulic Machinery (Group 08C) . 265
XXXIV MANPOWER, GRANTS, AND FACILITIES - Research Facilities (Group 09C). 266
XXXV AUTHOR INDEX. 267
XXXVI SUBJECT INDEX 285

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The efforts of Ms. Sue Eastman, Ms. Mary Lindburg, and Ms. Melanee Lowdermilk in preparing the necessary forms which are forwarded to the Water Resources Scientific Information Center are sincerely appreciated, as well as the typing of this final report.

The scope of this literature abstracting effort has been delineated jointly by the senior author and project officer, Mr. Alvin L. Wood, Source Management Branch, Robert S. Kerr Environmental Research Laboratory, Environmental Protection Agency, Ada, Oklahoma. The cooperative efforts of the Project Officer in meeting with project personnel and reviewing the abstracting process have been very helpful and are sincerely appreciated.

SECTION I

WATER CYCLE

PRECIPITATION (GROUP 02B)

77:02B-001
EFFECTS OF SOIL, COVER CROP, AND NUTRIENT SOURCE ON MOVEMENT OF SOIL, WATER, AND NITROGEN UNDER SIMULATED RAIN-SLOPE CONDITIONS,
Hoyt, G.D., McLean, E.O., Reddy, G.Y., and Logan, T.J.
Ohio Agricultural Research and Development Center, Wooster, Ohio.
Journal of Environmental Quality, Vol. 6, No. 3, p 285-290, July-September, 1977.
2 fig, 7 tab, 22 ref.

Descriptors: *Soil erosion, *Runoff, *Simulated rainfall, *Model studies, *Ohio, Fertilizers, Soils, Nitrogen, Phosphorus, Potassium, Farm wastes, Crops, Slopes, Ureas, Rainfall intensity, Time, Leachate, Erosion, Soil contamination.

Nitrogen, P, and K as manure, chemical fertilizers + straw, or chemical fertilizers alone were added to microplots of soils, which were then either cropped to wheat or left bare, and finally subjected to simulated rainfall. The N, P, and K were each applied at 224 kg/ha in the forms of: (1) N- and P-enriched cow manure (7.35 metric tons/ha, dry weight); (2) urea, triple-superphosphate (TSP), and KCl + straw at the same weight of dry matter as the manure; and (3) fertilizers alone. A 5-day rainfall sequence was imposed with varying intensities, durations, and soil slopes. The movement of N generally increased as the quantities of solids, runoff, and leachate increased. Where discrepancies occurred, they could usually be explained by differences in structure, crusting of the soils, or clogging of their pores by manure, or by effects of straw on soil permeability to water or on increased microbial activity. In general, almost all the mineral N moving in the leachate, and about half of that moving in runoff, was in NO3 form.

77:02B-002
COMPUTATION OF INFILTRATION FOR UNSTEADY UNINTERRUPTED HIGH RAINFALL,
Morel-Seytoux, H.J., Pick, T.A., and Jonch-Clausen, T.
Colorado State University, Engineering Research Center, Fort Collins, Colorado.
Journal of Hydrology, Vol. 35, No. 3/4, p 221-234, November 1977. 7 fig, 1 tab, 21 ref.

Descriptors: *Infiltration, *Rainfall, *Model studies, Mathematical models, Precipitation (atmospheric), Ponding, Runoff, Equations, Formulas, Hydrographs, Hydraulic conductivity, Precipitation intensity, Precipitation excess, Soils, Soil water movement, Percolation, Permeability, Soil properties, Rainfall patterns.

The use of previously proposed formulas for rainfall infiltration demonstrated the sensitivity of the response hydrographs to the rainfall pattern. For steady rainfall, the proposed formulas of ponding time and of infiltration rate after ponding were verified by comparison with experimental data. For unsteady rainfall, inspection of the formulas indicated that they may be in serious error for low-intensity rains of long duration.

SECTION II

WATER CYCLE

SNOW, ICE, AND FROST (GROUP 02C)

77:02C-001
WATER AND ICE POTENTIALS IN FROZEN SOILS,
Groenevelt, P.H., and Kay, B.D.
Guelph University, Department of Land Resource Science, Ontario, Canada.
Water Resources Research, Vol. 13, No. 2, p 445-449, April 1977. 3 fig, 19 ref.

Descriptors: *Frozen soils, *Moisture content, *Ice, *Model studies, Mathematical models, Porous media, Soils, Soil water, Voids, Hysteresis, Temperature, Freezing, Frozen ground, Frost, Frost action.

The envelope pressure potentials of the liquid water and ice in a frozen soil were identified. The envelope pressure potential of liquid water is a generalization of the definition of the envelope pressure potential (overburden potential) of the water in an unfrozen swelling soil. In order to express the envelope pressure potentials in terms of volume ratios, use was made of the void ratio, the moisture ratio equivalent, and the ice ratio equivalent. A new development was initiated by the formulation and derivation of the frost potential of both the liquid water and the ice. These frost potentials were expressed in terms of the ice ratio, the moisture ratio, the ice ratio equivalent, and the moisture ratio equivalent. The relations between these variables are intrinsic properties of the porous medium which have to be determined experimentally.

SECTION III

WATER CYCLE

EVAPORATION AND TRANSPIRATION (GROUP 02D)

77:02D-001
DETERMINATION OF REGIONAL EVAPOTRANSPIRATION FROM UPPER AIR METEOROLOGICAL DATA,
Mawdsley, J.A., and Brutsaert, W.
Cornell University, School of Civil and Environmental Engineering, Ithaca, New York.
Water Resources Research, Vol. 13, No. 3, p 539-548, June 1977. 6 fig, 7 tab, 27 ref, 1 append.

Descriptors: *Evapotranspiration, *Estimating, *Nebraska, *Iowa, Model studies, Mathematical models, Atmosphere, Weather data, Meteorological data, Hydrologic aspects, Boundary processes, Boundary layers, Evaporation, Equations, Data processing, Analysis, Theoretical analysis, Analytical techniques, Watersheds (basins), Correlation analysis, Monthly.

A procedure, recently proposed by the authors to calculate actual evapotranspiration on the basis of parameterization of the atmospheric boundary layer, was applied for the period April through November 1969-1972 with upper air ("rawinsonde") meteorological data from Omaha, Nebraska. The accuracy of the 1-day, 3-day, weekly, and monthly evapotranspiration totals was assessed by comparing them to evapotranspiration data estimated by a suitable adjustment of potential evapotranspiration from a nearby catchment in the Treynor basins. Several alternative methods for determining the height of the boundary layer and the wind speed at the top of the boundary layer were used: as a result, seven variations of the basic procedure were tested. The similarity functions for water vapor D were found to be smaller than the corresponding functions for sensible heat C, not equal as was assumed previously. Difficulties were encountered, since published upper air humidity data were in error: nevertheless, the method was successful on a monthly basis with a correlation coefficient of the order of 0.83, but far less successful on a daily basis. The recommended version of the method used the height of the temperature inversion as an estimate of the boundary layer height and the measured wind as the estimate of the boundary layer height and the measured wind as the estimate of the wind speed at the top of the boundary layer.

77:02D-002
EFFECT OF INCREASING FOLIAGE REFLECTANCE ON THE CO2 UPTAKE AND TRANSPIRATION RESISTANCE OF A GRAIN SORGHUM CROP,
Moreshet, S., Stanhill, G., and Fuchs, M.
Volcani Institute of Agricultural Research, Division of Agricultural Meteorology, Bet-Dagan (Israel).
Agronomy Journal, Vol. 69, p 246-250, March-April, 1977. 6 fig, 3 tab, 7 ref.

Descriptors: *Reflectance, *Leaves, *Photosynthesis, *Transpiration control, *Grain sorghum, Solar radiation, Dry farming, Crop response, Crop production, Spectrophotometry, On-site tests.

Two years of field studies of labeled CO2 uptake rates on kaolin-sprayed and unsprayed sorghum leaves indicated the coating caused a 23% decrease in net photosynthesis similar to the 26% reduction of solar radiation absorption detected with a spectrophotometer after spraying. Measurements were made during the rainless summers of 1973 and 1974 on an unirrigated sorghum crop (Sorghum bicolor L. Moench 'Hazera 726') in the Lakhish area of Israel. Grain yield increases had occurred after whitening of the crop canopy. Decreased photosynthesis persisted for several weeks and was greater 6 weeks after the last kaolin application. Most leaves had a slightly increased leaf resistance as well as reduced CO2 uptake; both effects were accentuated by high insulation. Enhanced senescence of the kaolin-coated leaves was confirmed by measurements of the dynamics of light-dependent CO2 uptake of leaves of different ages using neutral filters and independent measurements of green leaf area. However, field measurements with a diffusion porometer indicated only slight reductions in the leaf surface diffusion resistance of coated leaves. A possible explanation is presented to reconcile the decrease in photosynthesis with the observed grain yield increase of treated sorghum.

77:02D-003
ASSESSMENT OF WATER LOSS PATTERNS WITH MICROLYSIMETERS,
Rogowski, A.S., and Jacoby, E.L., Jr.
Agricultural Research Service, Northeast Watershed Research Center, University Park, Pennsylvania.
Agronomy Journal, Vol. 69, No. 3, p 419-424, May-June, 1977. 5 fig, 3 tab, 4 ref.

Descriptors: *Evapotranspiration, *Lysimeters, *Soil water, *Water loss, Soil water movement, Measurement, On-site tests, Laboratory tests, Nuclear moisture meters, Model studies.

In order to develop a practical method of evaluating evapotranspiration (ET) in the field, portable cylindrical grass-growing lysimeters were constructed and tested on a 58-ha watershed. A laboratory check indicated there was no loss of flow continuity with periodic lysimeter removal at high soil water levels. A field check proved feasibility for field use and indicated no significant differences in ET between different segments of a small study area. The watershed study also included gamma-probe measurements and ET predictions with a Blackland ET model. A number of strategically placed microlysimeters may estimate an ET component over a larger area as long as the predominant rooting depth is about 30 cm. Only very stony and wooded sites presented ET estimation problems for any of the three methods.

77:02D-004
EVAPORATION AND SALT MOVEMENT IN SOILS IN THE PRESENCE OF WATER TABLE,
Hassan, F.A., and Ghaibeh, A. Sh.
Alexandria University, Department of Soils and Water Science, Alexandria, (Egypt).
Soil Science Society of America Journal, Vol. 41, No. 3, p 470-478, May-June, 1977. 8 fig, 3 tab, 6 ref.

Descriptors: *Soil moisture, *Evaporation, *Salts, Soil water, Soil water movement, Model studies, Mathematical models, Laboratory tests, Loam, Clays, Foreign countries, Soils, Foreign research, Profiles, Soil profiles, Moisture tension, Hydraulic conductivity, Tensiometers, Soil physics, Soil science.

Evaporation from homogeneous and stratified columns, in the presence of shallow water table, at steady-state, was examined. Soils from Syria and Egypt were used. The hydraulic conductivity-moisture tension curves of the soils were determined and were fitted to smooth curves represented by Gardner's empirical formula. Solutions obtained by Gardner for the steady flow equations were modified for the boundary conditions of the top and bottom layers, and then the solutions were reduced to a dimensionless form with two variables, the relative flux density and the relative tension at the interface. The resulting equations were used to calculate the evaporation rates. Salt profiles near the surface, at different evaporation rates, also were studied. In case of homogeneous soil columns, the calculated values gave close estimates of the measured evaporation rates. However, the ratio of the calculated to measured rates was 1.3 to 1.6 for stratified columns. The salt profiles in the top dry layer indicated the polyphasic nature of water movement in the top zone. The observed increase in the dispersion coefficient with the solution velocity was more pronounced in soils of wider range of pore size.

77:02D-005
EVALUATION OF AN EVAPOTRANSPIRATION MODEL FOR CORN,
Rosenthal, W.D., Kanemasu, E.T., Raney, R.J., and Stone, L.R.
Kansas State University, Department of Agronomy, Manhattan, Kansas.
Agronomy Journal, Vol. 69, No. 3, p 461-464, May-June, 1977. 4 fig, 1 tab, 16 ref.

Descriptors: *Evapotranspiration, *Model studies, *Corn (field), *Kansas, *Soil water, On-site tests, Computer models, Input-output analysis, Irrigation practices, Meteorological data, Withdrawal, Soil profiles, Crop response.

An empirical evapotranspiration model was developed and tested for corn (Zea mays (L.) cv. Dekalb XL72A) grown on two sites in Kansas; soil water estimates determined by the computerized model were compared with neutron attenuation estimates. Required daily inputs for the model include leaf area index, solar radiation, effective precipitation and maximum and minimum air temperatures; outputs include transpiration, evaporation, advective contribution and soil water content. Model estimates were within 6% of neutron attenuation estimates during the growing season. The greatest water use efficiency and yield was achieved with an irrigation treatment involving 40% depletion of the maximum available water in the 150-cm profile. The model used has potential in scheduling irrigation on corn since required meteorological inputs can be routinely obtained at the field site. Leaf area index must be measured, estimated from remote sensing techniques, or simulated from leaf growth models.

77:02D-006
SURFACE ROUGHNESS OF CROPS AND POTENTIAL EVAPOTRANSPIRATION,
Slabbers, P.J.
International Institute for Land Reclamation and Improvement, Wageningen (Netherlands).
Journal of Hydrology, Vol. 34, No. 1/2, p 181-191, July 1977. 5 fig, 4 tab, 25 ref.

Descriptors: *Evapotranspiration, *Roughness coefficient, *Crops, Winds, Grasses, Climatology, Arid climates, Wind velocity, Foreign countries, Foreign research.

A roughness function for grass was derived by Rijtema for climatological conditions in The Netherlands. The function depends on wind speed and crop length and was used to determine the aerodynamics resistance of grass when calculating potential evapotranspiration. An analysis was made of data collected in southern Iran and of data that had been published for northern Iran, Lebanon, and Tunisia to determine whether the function also could be used in calculating crop water requirements under semi-arid and arid conditions. Except for some deviating data for which explanations were presented, agreement was obtained for all crops tested against the original relationship for grass. The importance of taking crop roughness into account in the combination equation, especially for relatively tall crops, was stressed.

77:02D-007
WATER REQUIREMENTS FOR MESQUITE (PROSOPIS JULIFLORA),
Tromble, J.M.
Agricultural Research Service, Southwest Watershed Research Center, Tucson, Arizona.
Journal of Hydrology, Vol. 34, No. 1/2, p 171-179, July 1977. 4 fig, 2 tab, 11 ref.

Descriptors: *Water requirements, *Mesquite, *Evapotranspiration, Runoff, Indexing, Water users, Water table, Vegetation, Water resources, Water utilization.

Evapotranspiration (ET) determined by different investigators, compared with values determined by the White and Troxell methods, showed that their values provided reasonable estimates and that utilizing diurnal water table fluctuations furnished a method of computing ET with less than 100% vegetation density. Average daily maximum ET rates for June were calculated, and ratios were compared with values from other independent studies. Since ET rates, determined by White and Troxell methods, indicated plausible values of water use when compared to other independent studies, the ET rates could be considered index values useful as guidelines for water abstracted by mesquite. Water table elevation measurements on a shallow perched aquifer under a mesquite thicket were used to calculate ET for time periods when the water table elevation varied diurnally. Average daily maximum ET values for June, when annual ET rates were highest, for the three years as predicted by the daily rate, White and Troxell methods were 1, 61, 10.10 and 12.17 mm, respectively.

77:02D-008
SAP STREAM VELOCITY AS AN INDICATOR OF THE TRANSPIRATIONAL PROCESS,
Balek, J., and Pavlik, O.
Ceskoslovenska Akademie Ved, Institute of Hydrodynamics, Prague.
Journal of Hydrology, Vol. 34, No. 1/2, p 193-200, July 1977. 4 fig, 6 ref.

Descriptors: *Transpiration, *Meteorological data, *Temperature, Water circulation, Radiation, Pressure, Rainfall, Heat flow, Foreign countries, Foreign research.

Continuous long-term measurements of the spruce sap stream velocity and meteorological phenomena observed in the Sumava region, Czechoslovakia, indicated two different relationships between sap stream velocity as a dependent variable and meteorological factors as independent variables. For mean daily temperatures above 6 C, the net radiation was found to be the most decisive factor; while for the temperatures below 6 C, the duration of rainfall during each particular day was found to be the most significant. Comparative results for the popular tree were provided. The results served as a transpiration variability indicator for the water balance circulations.

77:02D-009
MODELING SOIL WATER MOVEMENT INTO PLANT ROOTS,
Slack, D.C., Haan, C.T., and Wells, L.G.
Minnesota University, Department of Agricultural Engineering, St. Paul, Minnesota.
Transactions of the American Society of Agricultural Engineers, Vol. 20, No. 5, p 919-927, 933, September-October 1977. 7 fig, 1 tab, 48 ref.

Descriptors: *Soil water movement, *Soil-water-plant relationships, *Evapotranspiration, *Corn (field), Root systems, Leaves, Plant physiology, Laboratory tests, Model studies, Mathematical models, Soil water, Soil properties, Hydraulic conductivity, Evaporation, Agriculture.

A mathematical model was developed which describes uptake of water by plant roots as a function of leaf and soil water potentials. The model was used to estimate transpiration from corn grown in a controlled environment under soil drying conditions. The model predicted daily transpiration quite well for the period modeled.

77:02D-010
IMPROVING WATER USE IN SPRINKLING FOR BLOOM DELAY,
Barfield, B.J., White, G.M., Bridges, T.C., and Chaplin, C.
Agriculture Engineering Department, Horticulture Department, University of Kentucky, Lexington, Kentucky.
Transactions of the American Society of Agricultural Engineers, Special Edition, Vol. 20SW, p 688-691, 696, August 20, 1977. 5 fig, 8 ref, 1 equ.

Descriptors: Sprinkler irrigation, Cooling, Peaches, Fruit crops, Evaporation, Mist, Transpiration, Frost protection.

Bud development was delayed on Redhaven peach trees in 1975 by using evaporative cooling from sprinkler irrigation when bud temperatures exceeded 4.4 C. 104 cm of water were applied. Analysis was made of the potential reduction in water use and cooling that would have been obtained if sprinkling had been initiated at bud temperatures ranging from 4.4 to 9 C whenever cooling potential existed. Cooling potential was measured by the difference between dry bulb temperature and wet bulb temperature. The optimum set points for initiating sprinkling were found to be a dry bud temperature of 6.7 C and a cooling potential of 2.0 C.

77:02D-011
A SIMPLIFIED MODEL OF CORN GROWTH UNDER MOISTURE STRESS,
Childs, S.W., Gilley, J.R., and Splinter, W.E.
Agricultural Engineering Department, University of Nebraska, Lincoln, Nebraska.
Transactions of the American Society of Agricultural Engineers, Special Edition, Vol. 20SW, p 858-865, October 20, 1977. 7 fig, 3 tab, 21 ref, 15 equ.

Descriptors: Mathematical models, Soil moisture, Corn, Transpiration, Soil-plant-water relationships, Evaporation, Plant growth, Crop production, Nebraska, Water conservation, Hydraulic conductivity.

A mathematical model was developed to simulate the environmental and physiological processes involved in the growth of corn. Grain yields were accurately predicted even where inadequate irrigation caused decreased yield. Some predictions of crop growth patterns indicated that all of the dynamics of crop growth are not yet modeled in sufficient detail. However, the accuracy of growth trends in general indicate that the model has considerable predictive power.

SECTION IV

WATER CYCLE

STREAMFLOW AND RUNOFF (GROUP 02E)

77:02E-001
PRINCIPLES OF GRAPHICAL GRADUALLY VARIED FLOW MODEL,
Kouwen, N., Harrington, R.A., and Solomon, S.I.
Waterloo University, Department of Civil Engineering, Ontario, Canada.
Journal of the Hydraulics Division, American Society of Civil Engineers,
Vol. 103, No. HY5, Proceedings Paper 12939, p 531-541, May 1977. 7 fig, 5 ref,
2 append.

Descriptors: *Backwater, *Model studies, *Flow, *Graphical analysis, Computers, Gradually varied flow, Graphical methods, Hydraulics, Open channel flow, Flow profiles, Equations, Rivers.

Any gradually varied flow computation requires the solution of the energy and continuity equations. To this end, many techniques are available. For prismatic channels, the Direct Step Method gives a result without requiring iteration. However, for nonprismatic channels, it is necessary to resort to some variation of the Standard Step Method, thereby requiring some iterative procedure. A graphical solution, using a simple program to construct a set of curves, can eliminate iteration as well as retain flexibility with regard to flow variations along the reach. To accomplish this, a graphical solution of the energy equation was presented which uses hydraulic transform graphs for river cross sections along a reach.

77:02E-002
EVALUATION OF THE COMPONENTS OF THE USDAHL-74 MODEL OF WATERSHED HYDROLOGY,
Hanson, C.L.
United States Department of Agriculture, Agricultural Research Service, Department of Agricultural Engineering, Boise, Idaho.
Presented at the 1977 Winter Meeting of the American Society of Agricultural Engineers, December 13-16, 1977, Palmer House Hotel, Chicago, Illinois, p 1-8.
7 fig, 4 tab, 8 ref.

Descriptors: Model studies, Hydrology, Simulation analysis, Soil water, Runoff, Idaho, Computer programs.

The USDAHL-74 revised model of watershed hydrology was evaluated on an 83-ha arid rangeland watershed in southwest Idaho. The model simulated soil water adequately, except during periods in late summer and fall. The model did not adequately simulate runoff.

77:02E-003
AGRICULTURE RUNOFF MANAGEMENT (ARM) MODEL--VERSION II. REFINEMENT AND TESTING,
Donigian, A.S., Jr., Beyerlein, D.C., Davis, H.H., Jr., and Crawford, N.H.
Hydrocomp, Incorporated, Palo Alto, California 94304.
Publication No. EPA-600/3-77-098, August 1977. 294 p, 108 fig, 17 tab, 3 append.

Descriptors: Watersheds, Georgia, Michigan, Hydrology, Pesticides, Sediments, Nutrients, Runoff, Water quality, Model studies.

The Agricultural Runoff Management (ARM) Model has been refined and tested on small agricultural watersheds in Georgia and Michigan. The ARM Model simulates the hydrology sediment production, pesticide, and nutrient processes on the land surface and in the soil profile that determine the quantity and quality of agriculture runoff. This report discusses the research and model refinements related to soil moisture and temperature simulation, pesticide degradations, nutrient transformations and plant nutrient uptake. The goal is to evaluate and improve the pesticide and nutrient simulation capabilities of the ARM Model. However, the runoff and sediment modeling is also analyzed since these are the critical transport mechanisms of agricultural chemicals.

77:02E-004
RUNOFF FREQUENCY FROM SMALL STORMS AND IMPLICATIONS FOR WATER QUALITY,
Lewis, R.B., Hauser, V.L., Menzel, R.G., and Ross, J.D.
Agricultural Research Service, Water Quality Management Laboratory, Durant, Oklahoma.
Transactions of the American Society of Agricultural Engineers, Vol. 20, No. 4, p 661-665, July-August, 1977. 8 fig, 4 tab, 10 ref.

Descriptors: *Runoff, *Nebraska, *Water quality, *Agricultural chemicals, Onsite investigations, Watersheds (basins), Agricultural watersheds, Agricultural runoff, Chemicals, Farm management, Contour farming, Crops, Field crops, Storms, Storm runoff, Precipitation (atmosphere), Pollutants, Water pollution, Water pollution control.

The concentration of chemicals in surface runoff water is often an important consideration. Water soluble chemicals which are applied to the surface of plants or soil may appear in highest concentration in runoff from small storms. Therefore, some aspects of water quality management require quite different hydrologic information than has been required to solve problems considered in the past. The study of small storms in the central Great Plains near Hastings, Nebraska, revealed much about small storms and their relation to water quality. Compared with straight row cultivation, contouring of corn substantially decreased the number of runoff events resulting from small storms, and thus substantially decreased the probability of pollution from surface applied chemicals. The data showed that wheat on contour produced about 1/3 less annual runoff than wheat grown with straight row tillage; however, no difference was found between contour and straight row wheat in the number of runoff events resulting from small storms. During the months when it is desirable to top-dress nitrogen fertilizer on winter wheat, there is little or no threat of pollution to surface waters. Few runoff events were produced by small storms falling on meadow or pasture; therefore, chemicals may safely be applied to them. During June, the high rainfall month, there were 5 times more small storms producing no runoff than storms which did on all cultivated crops except corn with straight row tillage. Thus, if chemicals are applied only when the soil surface is relatively dry, the probability of surface-water pollution would be small.

77:02E-005
MANNING N AND THE OVERLAND FLOW EQUATION,
Ree, W.O., Wimberly, F.L., and Crow, F.R.
Agricultural Research Service, Stillwater, Oklahoma.
Transactions of the American Society of Agricultural Engineers, Vol. 20, No. 1, p 89-95, January-February, 1977. 7 fig, 5 tab, 9 ref.

Descriptors: *Mannings equation, *Watersheds (basins), *Overland flow, *Model studies, Laboratory tests, Small watersheds, Hydrograph analysis, Grassed waterways, Range grasses, Flow, Runoff, Vegetation, Channel flow, Hydraulics, Hydrology.

Manning n values for the overland flow surfaces of a grassed watershed were derived by hydrograph analysis and by using average watershed slope and overland flow length values determined by geomorphic methods. These values were compared with Manning n values from laboratory tests on channels having similar grass covers. Close agreement was found for poor grass, but not for fair and good grass. The methods can be used to estimate the overland flow equation for an ungaged watershed if a Manning n value for the overland flow surface can be estimated.

77:02E-006
COMPARISON OF ANNUAL STREAMFLOW MODELS,
Burges, S.J., and Lettenmaier, D.P.
Washington University, Department of Civil Engineering, Seattle, Washington.
Journal of the Hydraulics Division, American Society of Civil Engineers, Vol. 103, No. HY9, p 991-1006, September 1977. 9 fig, 1 tab, 22 ref, 2 append.

Descriptors: Model studies, Streamflow, Water resources, Streamflow forecasting.

The principle objective of this paper is to demonstrate the operational importance of the form of model and the level of its parameters used for annual streamflow generation. Streamflow generation models most commonly used in practice at present belong to the short-term memory category; models that preserve longer term persistence features (Hurst effect (10, 11, 12)) are well understood but have not been extensively used in water resource system evaluation. Models of the second category are usually more expensive to operate than Markov models; thus it is of interest to determine the operational importance of preserving both short and long-term persistence effects.

SECTION V

WATER CYCLE

GROUNDWATER (GROUP 02F)

77:02F-001
NUMERICAL PUMPING TEST ANALYSIS IN UNCONFINED AQUIFERS,
Rushton, K.R., and Chan, Y.K.
Birmingham University, Department of Civil Engineering, England.
Journal of the Irrigation and Drainage Division, American Society of Civil Engineers, Vol. 103, No. IR1, Proceedings Paper 12782, p 1-12, March 1977. 4 fig, 2 tab, 14 ref, 2 append.

Descriptors: *Aquifer testing, *Drawdown, *Numerical analysis, *Aquifers, Water table, Computer models, Darcy's law, Groundwater movement, Water wells, Test wells, Seepage, Storage, Percolation.

A numerical model was presented which describes the flow towards an abstraction well in an unconfined aquifer. At each radius, the conditions within the aquifer are described in terms of only two drawdowns, the free surface, and the average drawdown. This model allowed the effects of vertical components of flow, variable saturated depth, water contained within the well, delayed yield, and other factors to be included in a single solution. Results from the numerical model were compared with alternative analytical solutions. Finally, the technique was used to interpret two pumping tests in unconfined aquifers.

77:02F-002
TOWARD AN ANALYTICAL THEORY OF WATER FLOW THROUGH INHOMOGENEOUS POROUS MEDIA,
Gupta, V.K., Sposito, G., and Bhattacharya, R.N.
Arizona University, Department of Hydrology and Water Resources, Tucson, Arizona.
Water Resources Research, Vol. 13, No. 1, p 208-210, February 1977. 10 ref,

Descriptors: *Porous media, *Groundwater movement, *Darcy's law, Flow, Fluid mechanics, Analytical techniques, Mathematical studies, Equations, Mathematics, Analysis.

Some rigorous mathematical results for the Buckingham-Darcy flux law for water flow through an isotropic, nondeformable, inhomogeneous porous medium were presented. It was shown that the volumetric flux density vector, aside from the component due to gravity, may always be expressed in terms of a scalar and a vector matric flux potential. The vector matric flux potential will vanish for a homogeneous porous medium and for a one-dimensional inhomogeneous porous medium. It follows from this result that the hydraulic conductivity will be a function only of the water potential in any one-dimensional porous medium if its space derivative at constant water potential vanishes identically. In addition, it was shown that the vector matric flux potential is of no physical consequence insofar as the flow equation is concerned, regardless of the number of dimensions of space. The specifications of that part of the flux density vector contributed by the vector potential appears in the law of momentum balance instead of the law of mass balance.

77:02F-003
COMPARISON OF ITERATIVE METHODS OF SOLVING TWO-DIMENSIONAL GROUNDWATER FLOW EQUATIONS,
Trescott, P.C., and Larson, S.P.
Geological Survey, Water Resources Division, Reston, Virginia.
Water Resources Research, Vol. 13, No. 1, p 125-135, February 1977. 13 fig, 1 tab, 20 ref.

Descriptors: *Groundwater movement, *Subsurface flow, *Model studies, *Mathematical models, *Equations, Methodology, Evaluation, Correlation analysis, Aquifer characteristics, Hydrogeology.

The efficiency of line successive overrelxation (LSOR) is compared with a two-dimensional correction procedure (2DC), the iterative, alternating direction implicit procedure (ADI), and the strongly implicit procedure (SIP) to solve finite-difference equations used to simulate several groundwater reservoirs. Three of the reservoirs are linear, two are isotropic areal problems, and the third is an anisotropic cross-section simulation. The fourth is a nonlinear water table aquifer with areas of this saturation. SIP is generally the best method for the linear simulations and with the addition of another iteration parameter is the only method that gives an adequate rate of convergence for the water table problem. LSOR with 2DC is competitive with SIP on isotropic and anisotropic linear problems that are dominated by no-flow boundaries. ADI is generally more efficient than LSOR if a good set of iteration parameters are used, but this advantage is offset by the relative ease of finding the best acceleration parameter for LSOR.

77:02F-004
DRAIN SPACING BASED ON DYNAMIC EQUILIBRIUM,
McWhorter, D.B.
Colorado State University, Department of Agricultural Engineering, Fort Collins, Colorado.
Journal of the Irrigation and Drainage Division, American Society of Civil Engineers, Vol. 103, No. IR2, Proceedings Paper 13022, p 259-271, June 1977. 3 fig, 4 tab, 13 ref, 2 append.

Descriptors: *Drains, *Water table, *Groundwater movement, *Mathematical models, Equations, Aquifers, Groundwater recharge, Hydraulic properties, Flow, Depth, Discharge (water), Saturated flow, Drawdown, Boundaries (surfaces).

Superposition was used to obtain an equation for the water table elevation between parallel drains in response to a periodic sequence of instantaneous recharge events of arbitrary volume and timing. The mathematical developments are especially useful for calculating the spacing of parallel-relief drains required to achieve a perscribed maximum water table elevation under conditions of "dynamic equilibrium." A drain-spacing calculation, compared with the results obtained by the Bureau of Reclamation's (USDI) approximate, dynamic-equilibrium method, showed the latter to result in a drain spacing that is on the safe side. The spacing method reported herein provides a mathematically correct alternative to the pioneering dynamic equilibrium calculation and maintains the flexibility required to handle conditions of variable recharge and drainout times.

77:02F-005
INFLUENCE OF MATRIX CONDUCTION UPON HYDROGEOPHYSICAL RELATIONSHIPS IN ARENACEOUS AQUIFERS,
Worthington, P.F.
National Physical Research Laboratory, Geophysics Division, Pretoria (South Africa).
Water Resources Research, Vol. 13, No. 1, p 87-92, February 1977. 4 fig, 10 ref.

Descriptors: *Resistivity, *Sand aquifers, *Porosity, *Aquifers, Permeability, Geophysics, Sandstones, Electrolytes, Groundwater, Salinity, Particle size, Clay minerals.

The relationship of formation resistivity factor to effective porosity or intergranular permeability in water-saturated sands was shown to be best defined where the solid constituents do not contribute significantly to the conduction of applied current or where corrections for this contribution have been applied to the measured formation resistivities. It was demonstrated that, in the particular case of an argillaceous sand sorted according to its matrix conduction properties, useful relationships between formation resistivity factor and intergranular permeability can be established without any process of correction, provided that porosity and electrolyte salinity do not vary markedly within the formation. This finding was used to resolve the paradox that formation resistivity factor has been reported to increase with intergranular permeability in certain sands and to decrease with increasing values of this same hydrological parameter in others.

77:02F-006
DEVIATIONS FROM THE THEIS SOLUTION IN AQUIFERS UNDERGOING THREE-DIMENSIONAL CONSOLIDATION,
Gambolati, G.
Centro di Ricerca IBM di Venezia (Italy).
Water Resources Research, Vol. 13, No. 1, p 62-68, February 1977. 7 fig, 17 ref.

Descriptors: *Consolidation, *Aquifers, *Mathematical models. *Theoretical analysis, *Theis equation, Finite element analysis, Equations, Drawdown, Permeability, Aquifer testing, Storage coefficient, Depth, Compaction, Deformation, Stress,Potentiometric level, Elastic deformation.

Previously, a new mathematical model based on the "tension center" or "strain nucleus" concept was proposed for the response characterizing flow in a confined aquifer undergoing three-dimensional consolidation. The new approach differs from Biot's approach in that it leads to the development of a unique integrodifferential equation for the pressure head decline occurring within the porous system. The consideration of the horizontal strain components results in a conceptually simple modification of the classical diffusion equation to which a further integrodifferential term accounting for the three-dimensional effect is added. In the present paper, the new equation of flow was solved in a pumped artesian aquifer inclosed in a half space by an iterative finite element technique. It was shown that in shallow and relatively thick units (with W approximately equal to 0.5, where W is the ratio between the average depth and the thickness of the aquifer), downward vertical components of flow develop and that the average drawn deviates moderately from the Theis solution and is no longer uniquely represented against the dimensionless time. The three-dimensional effect produces an additional soil compression which retards the piezometric decline. At large values of time, the horizontal strain components vanish, the diffusion equation holds, and the solution becomes parallel to the Theis profile. As a major consequence, the traditional aquifer tests can still be applied to assess the formation permeability, but they yield a 40% overestimate of the elastic storage coefficient. In deeper units (W greater than 0.5), the importance of the three-dimensional effect diminishes, is already small when W equals 1, and becomes negligible for W greater than or equal to 2. In this case, the diffusion equation and its solutions are sufficiently accurate. From a practical standpoint, the quantitative results given herein are limited by the condition that a mechanically homogeneous and isotropic half space is required.

77:02F-007
THERMAL CONVECTION IN A CAVERNOUS AQUIFER,
Rubin, H.
Florida University, Department of Civil Engineering, Gainesville, Florida.
Water Resources Research, Vol. 13, No. 1, p 34-40, February 1977. 4 fig, 11 ref, 1 append.

Descriptors: *Thermal water, *Aquifers, *Groundwater movement, *Model studies, Mathematical models, Convections, Fluid mechanics, Fluid friction, Permeability, Groundwater, Temperature, Water temperature, Heat transfer, Currents (water), Stability, Equations, Porous media, Hydrology.

Geothermal activity may lead to convection currents in saturated permeable layers within the earth. Instability criteria for such a flow field, in which the fluid flows initially at moderate Reynolds numbers is discussed. Supercritical conditions were analyzed by expanding the finite amplitude perturbations through truncated eigenfunctions. This approach yielded expressions for the intensity of transport processes through the aquifer. It was found that mechanical dispersion due to convection motions reduces the intensity of transport processes.

77:02F-008
SHAPE OF A STREAMLINE WATER TABLE NEAR INFLOW AND OUTFLOW BOUNDARIES,
Boast, C.W.
Illinois University, Department of Agronomy, Urbana-Champaign, Illinois.
Water Resources Research, Vol. 13, No. 2, p 325-328, April 1977. 3 fig, 1 tab, 12 ref.

Descriptors: *Water table, *Shape, *Boundaries (surfaces), *Flow nets, Mathematical models, Inflow, Discharge, Slopes, Equations, Graphical analysis, Dupuit-Forchheimer theory, Dams.

A streamline water table usually is pictured to leave an inflow boundary perpendicular to the surface and to approach an outflow boundary tangential to the surface for vertical surfaces or for inclined surfaces with the porous medium "below" the surface. The hodograph solution for the problem of flow through a vertical walled dam proved that, theoretically, the water table streamline leaves the inflow boundary horizontally and approaches the outflow boundary vertically. However, the solution shows that at a practical scale the water table meets the boundaries at finite nonzero slopes. The actual water table shape deviates considerably from the usual way that the water table is sketched. The cause of the difference lies in an intuitive but incorrect assumption that the slope of the water table does not change dramatically near the endpoints of the water table.

77:02F-009
LOCATION OF FREE SURFACE IN POROUS MEDIA,
Liggett, J.A.
Cornell University, Department of Civil Environmental Engineering, Ithaca, New York.
Journal of the Hydraulics Division, American Society of Civil Engineers, Vol. 103, No. HY4, Proceedings Paper 12851, p 353-365, April 1977. 7 fig, 6 ref, 3 append.

Descriptors: *Free surfaces, *Porous media, *Mathematical models, Equations, Numerical analysis, Boundaries (surfaces), Groundwater movement, Water table, Steady flow, Unsteady flow, Permeability, Seepage.

The boundary integral equation method (BIEM) was applied to the problem of locating the free surface in both steady and unsteady flow through porous media. The method is numerical in its application and uses boundary data only. Thus, the position of the free surface can be found without solving the complete flow problem. The method can be continued to find the solution to the complete problem. The method is especially efficient when the solution is desired at a limited number of points (e.g., on a failure surface in determining slope stability) or in a limited area of the flow. Examples were given in which there is a free surface and a seepage surface and in which zones of different permeability appear.

77:02F-010
A METHOD OF ESTIMATING PARAMETERS AND ASSESSING RELIABILITY FOR MODELS OF STEADY STATE GROUNDWATER FLOW 1. THEORY AND NUMERICAL PROPERTIES,
Cooley, R.L.
Geological Survey, Water Resources Division, Lakewood, Colorado.
Water Resources Research, Vol. 13, No 2, p 318-324, April 1977. 1 fig, 37 ref.

Descriptors: *Model studies, *Groundwater movement, *Least squares method, *Steady flow, Hydrogeology, Numerical analysis, Aquifer characteristics, Geohydrologic units, Boundary layers, Sinks, Methodology, Forecasting, Regression analysis.

A new nonlinear least squares solution for the hydrogeologic parameters, sources and sinks, and boundary fluxes contained in the equations approximately governing two-dimensional or radial steady state groundwater motion was developed through use of a linearization and iteration procedure applied to the finite element discretization of the problem. Techniques involving (1) use of an iteration parameter to interpolate or extrapolate the changes in computed parameters and head distribution at each iteration and (2) conditioning of the least squares coefficient matrix through use of ridge regression techniques were proven to induce convergence of the procedure for virtually all problems. Because of the regression nature of the solution for the parameter estimation problem, classical methods of regression analysis are promising as an aid to establishing approximate reliability of computed parameters and predicted values of hydraulic head. Care must be taken not to compute so many parameters that the stability of the estimates is destroyed. Reduction of the error variance by adding parameters is desirable provided that the number of degrees of freedom for error remains large.

77:02F-011
TRANSIENT ANALYSIS OF PHREATIC AQUIFERS LYING BETWEEN TWO OPEN CHANNELS,
Singh, S.R., and Jacob, C.M.
Punjab Agricultural University, Department of Soil and Water Engineering, Ludiana (India).
Water Resources Research, Vol. 13, No. 2, p 411-419, April 1977. 3 fig, 1 tab, 16 ref.

Descriptors: *Aquifers, *Groundwater movement, *Hydrodynamics, *Model studies, Mathematical models, Groundwater, Channels, Hydraulic conductivity, Water table, Water levels, Precipitation (atmospheric), Infiltration, Recharge, Withdrawal, Hydraulics.

The unsteady-state flow of water through an unconfined aquifer can be represented by the Boussinesq equation. The nonlinear term involving the highest derivative in this equation was approximated by a linear term, and the resulting approximate Boussinesq was linearized to a Fokker-Planck equation by the method of functional transformation. Solutions to the problem of groundwater flow through phreatic aquifers lying between (1) constant water level boundaries and (2) variable water level boundaries were obtained from the general solution of the Fokker-Planck equation for constant and variable rates of recharge and withdrawal. Variable rates of recharge and withdrawal were approximated by periodic step functions which represented two different rates, one each for both rainy and dry seasons. Variable water levels in the open channels were approximated by step functions and the initial condition was represented by straight line segments. An analytical solution of the approximate Boussinesq equation was compared with the finite difference solution of the original Boussinesq equation. The difference between the two solutions was almost negligible, and therefore, the applicability of the analytical solutions to groundwater resource management was established. The effect of variable water level boundaries on groundwater dynamics was studied by performing a sample calculation.

77:02F-012
FLOW IN FRACTURED POROUS MEDIA,
Duguid, J.O., and Lee, P.C.Y.
Princeton University, Department of Civil Engineering, New Jersey.
Water Resources Research, Vol. 13, No 3, p 558-566, June 1977. 6 fig, 17 ref.

Descriptors: *Porous media, *Mathematical models, *Fracture permeability, *Flow, Model studies, Mathematical studies, Theoretical analysis, Analytical techniques, Numerical analysis, Finite element analysis, Equations, Porosity, Compressibility, Subsurface flow.

The equations governing the flow of fluid through fractured porous media were derived. The equations consist of Darcy's law for fluid flow in the primary pores, equations of motion for fluid flow in the fractures, and two continuity equations. The system of equations was coupled by the interaction of fluid in the primary pores with fluid in the fractures. The coupling terms, which are incorporated in the continuity equations, describe the transient flux of fluid out of the primary pores and into the fractures. The finite element Galerkin method was used to solve the coupled system of equations for transient flow in a confined leaky aquifer. Solutions were obtained for both constant discharge and step drawdown problems. The importance of coupling the primary blocks to the fracture system and the effect of the acceleration term in the equation of motion in the fractures were studied by using the model. The effect of the acceleration term in the equation of motion of fluid in fractures is small, even in the case of step drawdown, where there is a rapid change in the magnitude of velocity during early stages of the flow. Both the incremental pressure in the primary pores and the total incremental pressure in the fractures were obtained from the mathematical model. The two pressures cannot be obtained from an observation well because the level measured in the well is related to total pressure. The pressure in the fractures is nearly equal to the pressure in the primary pores, and the gradients of these pressures are nearly equal.

77:02F-013
VISCOELASTIC AQUIFER MODEL APPLIED TO SUBSIDENCE DUE TO PUMPING,
Corapcioglu, M.Y., and Brutsaert, W.
Cornell University, School of Civil and Environmental Engineering, Ithaca, New York.

Water Resources Research, Vol. 13, No 3, p 597-604, June 1977. 2 fig, 3 tab, 46 ref.

Descriptors: *Land subsidence, *California, *Mathematical models, *Aquifers, *Pumping, Model studies, Water level fluctuations, Compaction, Drawdown, Theoretical analysis, Consolidation.

A viscoelastic aquifer model was applied to analyze and predict the piezometric drawdown and the compaction observed in a major confined aquifer system in the San Joaquin Valley in California. A field approach was used based on a minimal number of "bulk" parameters. The parameters, which are the transmissivity, the compressibilities of primary and secondary consolidation, and the viscosity of the secondary consolidation, were derived by calibration of the model by means of trial and error simulation of 2 years of records of drawdown and compaction. It was found that in the absence of drawdown records, the identification also may be accomplished with compaction records in addition to a standard pumping test. Comparison of computed results with available records showed that the viscoelastic model yields a satisfactory prediction of compaction which is far better than that obtainable with the elastic model of the classical Theis-Jacob approach. The elastic model may be adequate to represent the hydraulic properties of the aquifer in the analysis of the piezometric drawdown; however, it appears to be unsatisfactory to represent the mechanical properties of the aquifer as related to surface subsidence.

77:02F-014

NUMERICAL MODEL FOR SATURATED-UNSATURATED FLOW IN DEFORMABLE POROUS MEDIA, I. THEORY,

Narasimhan, T.N., and Witherspoon, P.A.

California University, Lawrence Berkeley Laboratory; and California University, Department of Mineral Sciences and Mineral Engineering, Berkeley, California.

Water Resources Research, Vol. 13, No 3, p 657-664, June 1977. 6 fig, 27 ref.

Descriptors: *Porous media, *Mathematical models, *Groundwater movement, Theoretical analysis, Saturated flow, Unsaturated flow, Model studies, Deformation, Numerical analysis, Equations, Flow, Groundwater, Hydrology, Permeability, Compressibility, Pore water, Hydraulic conductivity.

A theory was presented for numerically simulating the movement of water in variable saturated deformable porous media. The theoretical model considered a general three-dimensional field of flow in conjunction with a one-dimensional vertical deformation field. The governing equation expressed the conservation of fluid mass in an elemental volume that has a constant volume of solids. Deformation of the porous medium may be nonelastic. Permeability and the compressibility coefficients may be nonlinearly related to effective stress. Relationships between permeability and saturation with pore water pressure in the unsaturated zone may be characterized by hysteresis. The relation between pore pressure change and effective stress change may be a function of saturation. In the transition zone where pore water pressure is less than atmospheric but greater than air entry value, soil moisture diffusivity as used in soil physics and coefficient of consolidation as used in soil mechanics were shown to be conceptually equivalent. It is believed that the model will be of practical interest in studying saturated-unsaturated systems undergoing simultaneous desaturation and deformation.

77:02F-015

SEEPAGE UNDER STRUCTURE ON N STRATA OF SOIL,

Lenau, C.W.

Missouri University, Department of Civil Engineering, Columbia, Missouri.

Journal of the Hydraulics Division, American Society of Civil Engineers, Vol. 103, No. HY5, Proceedings Paper 12911, p 483-497, May 1977. 4 fig, 2 tab, 2 ref, 4 append.

Descriptors: *Underseepage, *Stratification, *Hydraulic structures, *Mathematical models, Equations, Groundwater movement, Underflow, Seepage, Permeability, Aquifers, Confined water, Artesian heads, Dams.

A solution was developed for the discharge under a structure resting on N strata of equal thickness. The solution was an asymptotic approximation of the exact solution for large values of the structure length. However, because neglected terms are exponentially small, the solution is accurate for a very wide range of conditions. Because successive strata can have equal permeability, the solution can be applied to almost any combination of strata thicknesses and permeabilities.

77:02F-016
HYDROGEOCHEMICAL RELATIONSHIPS USING PARTIAL CORRELATION COEFFICIENTS,
Barr, D.E., and Newland, L.W.
Texas Christian University, Environmental Sciences Program, Fort Worth, Texas.
Water Resources Bulletin, Vol. 13, No. 4, Paper No. 77073, p 843-846, August 1977.
1 tab, 4 ref.

Descriptors: *Water chemistry, *Groundwater, *Correlation analysis, *Geochemistry, Ions, Cations, Calcium, Sodium, Magnesium, Chlorides, Sulfates, Data processing, Analytical techniques, Groundwater resources.

Analyses of 69 groundwater samples were performed for 6 chemical parameters. Partial and simple correlation coefficients for the parameters indicate that partial coefficients are superior to simple coefficients in establishing geochemical relationships for the aqueous system evaluated. The improved reliability arises from the ability of partial correlation analysis to hold constant the outside factors that may be affecting the two variables of interest.

77:02F-017
TRANSIENT SPHERICAL FLOW TO A CAVITY WELL OF FINITE DIAMETER,
Jaiswal, C.S., Chauhan, H.S., and Ghildyal, B.P.
Govind Ballabh Pant University of Agriculture and Technology, Department of Agricultural Engineering, Pantnagar (India).
Ground Water, Vol. 15, No. 5, p 372-376, September-October 1977. 4 fig, 3 tab, 12 ref.

Descriptors: *Flow, *Groundwater movement, *Wells, Transmissivity, Storage coefficient, Aquifers, Hydrology, Groundwater, Mathematical studies, Analysis.

The system of flow into a nonpenetrating well with hemispherical bottom of finite radius in a finite deep artesian aquifer of infinite radial extent was analyzed. The solution was obtained in terms of error function. A method was suggested for determination of transmissivity, storage coefficient, and depth of aquifer from pump test data of such wells discharging at constant rate. For small values of radial distance to aquifer depth ratio and for small duration test, only a few were required in the present solution as compared to the solution of Hantush developed for such wells.

77:02F-018
MODELING OF UNCONFINED GROUNDWATER SYSTEMS,
Murray, W.A., and Johnson, R.L.
Lehigh University, Department of Civil Engineering; and Lehigh University, Fritz Engineering Laboratory, Bethlehem, Pennsylvania.
Ground Water, Vol. 15, No. 4, p 306-312, July-August 1977. 2 fig, 1 tab, 34 ref, 2 append.

Descriptors: *Groundwater, *Equations, *Model studies, Groundwater movement, Dupuit-Forchheimer theory, Mathematical models, Water table, Hydrology, Base flow.

Mathematical modeling of regional unconfined groundwater flow is accomplished most often by using a linearized Dupuit-Forchheimer (DF) equation. The depth of flow, h, in the general DF equation appears as a squared h term and also as a linear term of h. Linearization of the DF equation generally is accomplished with the first method of linearization presented by Polubarinova-Kochina (PK), in which squared h is replaced with h times some average depth of flow. The resulting equation is then linear in h. The second method of linearization described by PK is accomplished by replacing h with squared h, divided by an average flow depth, and hence the resulting equation becomes linear in squared h. If the second method of linearization is used, the same heat conduction type equation is obtained as that from the first method of linearization, but it tends to yield more accurate predictions of water table locations. Furthermore, by simply altering the numerical values of boundary condition constants, most existing mathematical models, based on the first method of linearization can be easily converted to yield solutions to the more accurate equation linearized by the second method.

77:02F-019
DIGITAL MODEL STUDIES OF STEADY-STATE RADIAL FLOW TO PARTIALLY PENETRATING WELLS IN ALLUVIAL PLAINS,
Lakshminarayana, V., and Rajagopalan, S.P.
Indian Institute of Technology, Department of Civil Engineering, Kanpur.
Ground Water, Vol. 15, No 3, p 223-230, May-June 1977. 5 fig, 4 tab, 4 ref.

Descriptors: *Groundwater, *Groundwater movement, *Water wells, *Model studies, Mathematical models, Drawdown, Wells, Water levels, Water table, Flow, Aquifers, Screens, Well screens, Permeability, Anisotropy, Pumping, Computer models.

A digital simulation model for the steady-state radial flow towards partially penetrating wells in the alluvial plains was presented. As the deposits in these plains are heterogeneous with several good water-bearing formations crisscrossed with silty layers, the deposits were treated as a single anisotropic aquifer with water table conditions prevailing. The iterative alternate direction implicit technique was used for the solution of the steady-state flow. The digital simulation model was used to study the effects of anisotropy, screen setting, and screen length on the discharge per unit length of screen. The model also was used to evaluate the errors involved in determining lateral permeability from distance-drawdown data. The digital simulation model was applied to field pump-test data for purposes of identification of aquifer anisotropy and radius of influence of well; and the model was used in evaluation of errors in determining lateral permeability from distance-drawdown data.

77:02F-020
A MATHEMATICAL MODEL STUDY OF FRESH-WATER LENSES,
Chidley, T.R.E., and Lloyd, J.W.
Aston University, Department of Civil Engineering, Birmingham (England).
Ground Water, Vol 15, No 3, p 215-222, May-June 1977. 8 fig, 9 ref.

Descriptors: *Groundwater, *Islands, *Model studies, Mathematical models, Saline water-freshwater interfaces, Aquifers, Permeability, Water levels, Fluctuations, Water levels fluctuations, Groundwater movement, Groundwater recharge, Groundwater resources.

An analysis of the unsteady flow in a freshwater lens on a small tropical thickness. An alternative view of the problem to that most commonly given was presented. Results were shown for some lenses on Grand Cayman Island in the Caribbean Sea. The aquifer material is a micro-first limestone. The chief result of engineering significance was that the conventional steady-state analysis was shown to be a sound basis for estimating the long-term yield if drought sequences are not long.

77:02F-021
APPLICATIONS OF SURFACE RESISTIVITY METHODS,
Schwartz, F.W., and McClymont, G.L.
Alberta University, Department of Geology, Edmonton, Alberta, Canada.
Ground Water, Vol. 15, No. 3, p 197-202, May-June 1977. 5 fig, 10 ref.

Descriptors: *Groundwater, *Surveys, *Resistivity, *Canada, Geology, Geophysics, Rock properties, Conductivity, Electrical resistance, Borehole geophysics, Sandstones, Glacial drift, Aquifers, Groundwater potential, Groundwater resources, Hydrogeology.

Generally, the geology of the Breton area of Alberta consists of a 5- to 125-ft. veneer of glacial till overlying sandstone and sandy shale units of the Paskapoo Formation. These sandstone units are locally important aquifers. Glacial drift in the Hastings Lake area varies in thickness from 100 to 200 ft. and overlies the Horseshoe Canyon Formation, which consists of bentonitic shale, siltstone, and coal units with minor sandstone units. Groundwater yields from drift and bedrock in this area are generally less than 30 gpm (113.6 l/m). Resistivity soundings were completed at 68 and 65 stations in the Breton and Hastings Lake areas, respectively. Profile maps from the Breton area are characterized by broad areas with apparent resistivity values greater than 100 ohm-ft. Qualitative evaluation of the resistivity soundings and existing borehole data indicated that the high resistivity values resulted from a thick resistive sandstone aquifer less than 25 ft from ground surface. A reasonably well-defined resistivity pattern was evident on the profile maps of the Hastings Lake area, with the highest resistivity values coming from stations located in the hummocky moraine south of the lake. In addition to providing useful information on the geology of an area, surface resistivity methods provide a rapid and relatively inexpensive tool to aid in planning more detailed groundwater studies because of their ability to detect inhomogeneities in the subsurface environment.

77:02F-022
UTILIZING A DIGITAL MODEL TO DETERMINE THE HYDRAULIC PROPERTIES OF A LAYERED AQUIFER,
Land, L.F.
Geological Survey, Bay Saint Louis, Missouri.
Ground Water, Vol.15, No 2, p 153-159, March-April 1977. 6 fig, 1 tab, 13 ref.

Descriptors: *Model studies, *Hydraulic properties, *Aquifer systems, *Computer models, Groundwater movement, Hydraulic conductivity, Storage coefficient, Transmissivity.

The hydraulic characteristics of a layered groundwater system are determined by a modified digital model. Its use provides information on the hydraulic conductivity and storage coefficient of a stratum and on the transmissivity and storage coefficient of the groundwater system as a whole. These characteristics are determined by trial and error test runs until the calculated drawdowns reasonably match drawdown data from observation wells which are open to the artesian aquifer and to the confining beds above or below. An aquifer test of a layered groundwater system in Palm Beach County, Florida, shows that the transmissivity of the groundwater system as a whole is 50 percent higher than just the transmissivity of the major water-bearing zone in this system.

77:02F-023
ANALYTIC SOLUTION FOR DRAWDOWN IN AN UNCONFINED-CONFINED RECTANGULAR AQUIFER,
Chan, Y.K., Mullineux, N., and Reed, J.R.
Birmingham University, Department of Mechanical Engineering, (England).
Journal of Hydrology, Vol. 34, No. 3/4, p 287-296, August 1977. 3 fig, 2 ref, 1 append.

Descriptors: *Drawdown, *Aquifers, *Mathematical models, *Equations, *Rainfall, *Groundwater, Water wells, Pumping, Confined water, Aquifer characteristics.

Analytical solutions for the drawdowns due to pumping from a rectangular, unconfined-confined aquifer subject to rainfall on the unconfined part were given. A solution with general rainfall and with time counted from the start of abstraction was shown to involve more extensive computation than is usually warranted. The amount of computation can be very considerably reduced by considering the rainfall to be periodic (either x-dependent or uniform) and by seeking the eventual periodic drawdown. Since the problem is linear, the drawdown due to a number of abstraction wells in the confined aquifer is merely the sum of the drawdowns due to each individually.

77:02F-024
LONGITUDINAL DISPERSION IN POROUS MEDIA WITH VARIABLE POROSITY,
Lin, S.H.
Melbourne University, Department of Chemical Engineering, Parkville (Australia).
Journal of Hydrology, Vol 34, No 1/2, p 13-19, July 1977. 3 fig, 13 ref.

Descriptors: *Porous media, *Porosity, *Dispersion, Aquifers, Groundwater, Saline water intrusion, Hydrology, Equations, Model studies, Mathematical studies, Oil reservoirs.

An analytical procedure was developed for predicting the solute dispersion in porous media with variable porosity and constant volumetric seepage flow rate. Several porosity equations, which may represent the possible porosity variation as a function of spatial coordinate, were suggested and used to test how well the predicted solute concentration using a constant average porosity is when compared to the prediction using a prescribed porosity function. It was found that the predictions by using an average porosity are within 15% of those predictions using a linear or a slightly curved, porosity function. However, the discrepancy between the two predictions is very substantial as the porosity function becomes a strong nonlinear one. For this instance, prediction of the solute concentration using an average porosity is rather poor, and a numerical method is needed if a reliable prediction is to be obtained.

77:02F-025
COMPUTER MODELING OF REGIONAL GROUNDWATER SYSTEMS IN THE CONFINED-UNCONFINED FLOW REGIME,
Birtles, A.B., and Reeves, M.J.
Department of the Environment, Central Water Planning Unit, Reading (England).
Journal of Hydrology, Vol.34, No 1/2, p 97-127, July 1977. 13 fig, 47 ref.

Descriptors: *Groundwater, *Groundwater movement, *Model studies, Mathematical models, Aquifers, Sandstones, Infiltration, Discharge (water), Flow, Foreign research, Computer models, Recharge, Water levels, Pumping, Leakage, Hydrology.

The concepts and philosophies underlying the development of general purpose computer programs for the simulation of groundwater flow in regional aquifer systems operating in the confined-unconfined flow regime were described. The most important of the many variables at play in such systems and the mechanisms by which they interact were identified, and the data required for the numerical definition of the hydrological system were reviewed. Emphasis was laid upon the importance of modeling physical processes as precisely as possible when computer predictions outside the scope of natural hydrological events are to be attempted. An example was given of an application of the computer programs and techniques to the investigation of a proposed river regulation scheme using groundwater abstractions.

77:02F-026
PERMISSIBLE MESH SPACING IN AQUIFER PROBLEMS SOLVED BY FINITE DIFFERENCES,
Rushton, K.R., and Tomlinson, L.M.
Birmingham University, Department of Civil Engineering, Birmingham University (England).
Journal of Hydrology, Vol.34, No 1/2, p 63-76, July 1977. 6 fig, 4 tab, 12 ref, append.

Descriptors: *Aquifers, *Groundwater, *Model studies, Mathematical models, Finite element analysis, Groundwater movement, Analytical techniques, Computer models, Hydrology.

The maximum acceptable mesh spacing for finite-difference models of groundwater flow problems was investigated by analyzing a range of problems for which alternative solutions are available. It was shown that, for long time periods or for problems in which the head variation is smooth, a few mesh subdivisions are often acceptable; but for other problems, many mesh subdivisions are essential. Recommendations were given for the design of a mesh; the validity of the design was tested in the solution of two field problems.

77:02F-027
ECONOMIC IMPACT OF DIMINISHING GROUNDWATER RESERVES ON CORN PRODUCTION UNDER CENTER-PIVOT IRRIGATION,
Sanghi, A.K., and Klepper, R.
Washington University, Center for the Biology of Natural Systems, St. Louis, Missouri 63130.
Journal of Soil and Water Conservation, Vol. 32, No. 6, p 282-285, November-December, 1977. 4 tab, 18 ref.

Descriptors: Groundwater, Groundwater resources, Groundwater basins, Groundwater potential, Aquifers, Corn, Sprinkler irrigation, Irrigation, Nebraska, Crop response, Crop production, Water conservation.

A method for analyzing the on-farm economic consequences of diminishing groundwater reserves was developed. The method uses two functions. One relates well yield to an aquifer's saturated thickness. The other is a yield-response function that recognizes a critical period of plant growth. The application of the method to corn under center pivot irrigation in Holt County, Nebraska, showed net returns to be far more sensitive to insufficient irrigation water during the critical period of corn growth than to price increases for energy or other inputs. The analysis also suggested that farmers motivated by short-run economic gain will find it profitable to modify wells to sustain well yield as water tables decline. Conservation of groundwater, therefore, cannot be left to market forces.

77:02F-028
STUDIES ON SALINIZATION OF GROUNDWATER, I. THEORETICAL CONSIDERATION ON THE THREE-DIMENSIONAL MOVEMENT OF THE SALT WATER INTERFACE CAUSED BY THE PUMPAGE OF CONFINED GROUNDWATER IN FAN-SHAPED ALLUVIUM,
Kishi, Y., and Fukuo, Y.
Ehime University, Department of Applied Physics, Matsuyama (Japan).
Journal of Hydrology, Vol. 35, No. 1/2, p 1-29, October 1977. 8 fig, 8 ref, 2 append.

Descriptors: *Groundwater flow, *Sea water, *Saline water intrusion, *Saline water-freshwater interfaces, *Alluvial fans, Mathematical models, Confined water, Pumping, Equations, Numerical analysis, Hydraulic conductivity, Density, Darcy's law, Boundaries (surfaces).

A theoretical model was presented on the phenomenon of seawater intrusion into confined groundwater to make clear the relationship between the amount of pumping of freshwater and the corresponding three-dimensional spatial distribution of salt water. First, differential equations were derived for the fresh and salinized regions, respectively, from the fundamental equation of confined water. The equation in the salinized region, which is a quasilinear differential equation, can be transformed to a linear one and then is continued to the equation in the fresh region, resulting in the two-dimensional Poisson's equation which is applicable to the entire region. The equation in steady-state was solved in integral form by using the method of Green's functions and was expressed simply in the case of idealized field conditions analogous to a fan-shape alluvium by the usual method of images. Finally, some numerical examples were shown for the case of uniform pumpage in a circular region.

77:02F-029
SOLUTION OF THREE-DIMENSIONAL GROUNDWATER FLOW EQUATIONS USING THE STRONGLY IMPLICIT PROCEDURE,
Trescott, P.C., and Larson, S.P.
Geological Survey, Water Resources Division, Reston, Virginia.
Journal of Hydrology, Vol. 35, No 1/2, p 49-60, October 1977. 6 fig, 17 ref, append.

Descriptors: *Model studies, *Groundwater movement, *Aquifer characteristics, *Numerical analysis, *Computer programs, Hydrogeology, Leakage, Hydraulic conductivity.

A three-dimensional numerical model has been coded to use the strongly implicit procedure for solving the finite-difference approximations to the groundwater flow equation. The model allows for: (1) the representation of each aquifer and each confining bed by several layers; and (2) the use of an anisotropic hydraulic conductivity at each finite-difference block. The model is compared with a previously developed quasi-three-dimensional model by simulating the steady-state flow in an aquifer system in the Piceance Creek Basin, Colorado. The aquifer system consists of two aquifers separated by a leaky confining bed. The upper aquifer receives recharge from precipitation and is hydraulically connected to streams. In order to make a valid comparison of results, a single layer was used to represent each aquifer. The need for a layer to represent the confining bed was eliminated by incorporating the effects of vertical leakage into the vertical component of the anisotropic hydraulic conductivity of the adjacent aquifers. Thus, the problem was represented by only two layers in each model with a total of about 2,100 equations. This restricted the effects of flow in the confining layer to the vertical components, but simulations with a third layer in the three-dimensional model permitting horizontal flow in the confining bed show that the two-layer approach is reasonable. Convergence to a solution of this problem takes about one minute of computer time on the IBM/155. This is about 30 times faster than the time required using the quasi-three-dimensional model.

77:02F-030
CARBON DIOXIDE IN THE ATMOSPHERE OF THE UNSATURATED ZONE: AN IMPORTANT CONTROL OF GROUNDWATER HARDNESS IN LIMESTONES,
Atkinson, T.C.
University of East Anglia, School of Environmental Sciences, Norwich (England).
Journal of Hydrology, Vol. 35, No. 1/2, p 111-123, October 1977. 6 fig, 4 tab, 30 ref.

Descriptors: *Carbon dioxide, *Hardness (water), *Groundwater, *Limestones, Caves, Springs, Spring water, Calcium, Calcite, Alkalinity, Water chemistry, Organic material, Groundwater movement, Atmosphere, Unsaturated flow, Chemistry, Hydrogeology, Hydrology.

Weekly analyses of springwaters in the Mendip Hills, England, showed constant partial pressure of CO2. Soil air partial pressure of CO2 (measured directly and calculated from soil water analyses) fluctuates seasonally and is almost always less than the partial pressure of CO2 of springs. A source of CO2 in the unsaturated zone was proposed to account for the discrepancy, supported by direct measurements of CO2 in fractures in cave walls and analyses of drip waters. The partial pressure of CO2 increases with depth, and values at the bottom of caves are similar to spring waters. A possible source is decay of downwashed soil organic matter.

77:02F-031
MATHEMATICAL MODELING OF NATURAL GROUNDWATER RECHARGE,
Krishnamurthi, N., Sunada, D.K., and Longenbaugh, R.A.
Utah International Inc., Environmental Quality Department, San Francisco, California.
Water Resources Research, Vol. 13, No. 4, p 720-724, August 1977. 4 fig, 15 ref.

Descriptors: *Groundwater recharge, *Model studies, *Mathematical models, Soil water, Soil moisture, Capillary action, Pore pressure, Infiltration, Computer models.

A mathematical model was presented which determines natural groundwater recharge by using transient soil moisture data measured as a function of vertical position. The model was based upon the finite difference form of the Richards equation. The assumption was made that moisture content varies in the linear range of pressure-moisture and conductivity-moisture relations to obtain a solution to a particular field problem. The parameters of the model, estimated by a linear model of the moisture data, characterize the hydraulic properties of soil and their spatial variability. The finite difference form of the mathematical model was solved by iteration using the Newtonlike method, ensuring computational speed and accuracy. The model and the computer program were verified by using the first-order, approximate, one-dimensional solution of the infiltration equation for homogeneous soil. Application of the model to the High Plains of Colorado provided monthly recharge rates which correlate adequately with the time series data of water table elevations and events of precipitation and ephemeral streamflow.

77:02F-032
WATER TABLE RESPONSE TO A SEQUENCE OF RECHARGES,
Chu, S.T.
South Dakota State University, Department of Agricultural Engineering, Brookings, South Dakota.
Water Resources Research, Vol. 13, No. 4, p 738-742, August 1977. 3 fig, 3 tab, 11 ref.

Descriptors: *Water table, *Subsurface drainage, *Model studies, *Recharge, *Groundwater recharge, Mathematical models, Tile drainage, Soil water, Groundwater, Drainage, Fluctuations, Hydraulic conductivity, Agriculture.

Water table behavior under subsurface drainage conditions was analyzed by considering water table fluctuations in response to a sequence of recharge events. The derived solution is applicable to a nonhomogeneous soil profile. An iteration procedure was introduced to illustrate the application of the theoretical results. Agreement between theoretical analysis and field data was shown to be adequate.

77:02F-033
MACROSCOPIC DISPERSION IN POROUS MEDIA: THE CONTROLLING FACTORS,
Schwartz, F.W.
Alberta University, Department of Geology, Edmonton, Alberta, Canada.
Water Resources Research, Vol. 13, No. 4, p 743-752, August 1977. 7 fig, 10 ref,
1 append.

Descriptors: *Dispersion, *Porous media, *Model studies, *Groundwater movement, Mathematical models, Hydraulic conductivity, Permeability, Porosity, Pores, Soil water, Soil water movement, Soils, Soil science, Groundwater, Subsurface flow.

One of the most important limitations to the application of modeling techniques for the analysis of mass transfer in groundwater systems is the difficulty in characterizing the dispersive character of natural systems. Although large quantities of experimental data exist for laboratory scale experiments, the handful of measurements which have been obtained from regional systems suggest that dispersion produced by large-scale porous medium nonidealities is considerably more important. The effects of macroscopic dispersion were simulated for uniform heterogeneous porous media under conditions of one-dimensional flow. The idealized media considered for detailed analysis consisted of low-permeability inclusions within a higher-permeability medium. When the inclusions are not arranged rather homogeneously within the region, a unique dispersivity value for the medium cannot be defined, and dispersivity changes as a function of space. The magnitude of dispersion is controlled by the contrast in hydraulic conductivity between the inclusions and the remainder of the medium, the number of inclusions, and the mode of aggregation. Generally, dispersivity was found to decrease as the conductivity contrast decreases and the structure of the medium is regularized. It will be possible to estimate the dispersivity of a medium by using stochastic analysis. Hypothetical porous media with characteristics similar to those of some actual medium will yield a range of dispersivity values. The basic data for the technique will be detailed statistical analysis of the mode of porous medium aggregation and the conductivity contrasts within the medium.

77:02F-034
SIMILARITY SOLUTIONS FOR CONVECTION OF GROUNDWATER ADJACENT TO HORIZONTAL IMPERMEABLE SURFACES WITH AXISYMMETRIC TEMPERATURE DISTRIBUTION,
Cheng, P., and Chau, W.C.
Hawaii University, Department of Mechanical Engineering, Honolulu.
Water Resources Research, Vol. 13, No. 4, p 768-772, August 1977. 8 fig, 2 tab,
12 ref.

Descriptors: *Groundwater movement, *Convection, *Water temperature, *Model studies, Mathematical models, Porous media, Groundwater, Heat transfer, Temperature, Heat flow, Heated water, Velocity, Permeability.

The axisymmetric buoyancy-induced groundwater flow adjacent to horizontal impermeable surfaces, wall temperature being a power function of radius, was discussed in this paper. With the boundary layer simplifications, the governing nonlinear partial differential equations can be transformed into a coupled pair of nonlinear ordinary differential equations with two-point boundary conditions that can be integrated numerically by established techniques. Simple algebraic expressions for boundary layer thickness and heat transfer rate were obtained. Applications to free convective flow in a liquid-dominated geothermal system at high Rayleigh numbers were discussed.

77:02F-035
GROUNDWATER STORAGE RIGHTS IN THE WESTERN STATES,
Aiken, J.D.
Nebraska-Lincoln University, Department of Agricultural Economics, Lincoln,
Nebraska.

Presented at the 1977 Annual Meeting of the American Society of Agricultural Engineers, June 26-29, 1977, Raleigh, North Carolina, North Carolina State University, p. 1-17.

Descriptors: Groundwater, Groundwater recharge, Groundwater basins, Groundwater resources, Legal aspects, Legislation.

This paper summarizes statutes and related court cases from California and Washington relating to the artificial storage and recapture of groundwater. The paper also discusses some legal considerations states should consider in establishing regulations for the artificial storage of groundwater.

77:02F-036
GEOELECTRIC SOUNDING FOR ESTIMATING AQUIFER HYDRAULIC CONDUCTIVITY,
Kelly, W.E.
Rhode Island University, Department of Civil and Environmental Engineering, Kingston, Rhode Island.
Ground Water, Vol. 15, No. 6, p 420-425, November-December , 1977. 5 fig, 3 tab, 17 ref.

Descriptors: *Hydraulic conductivity, *Resistivity, *Electrical resistance, *Rhode Island, On-site investigations, Aquifers, Pump testing, Hydrologic properties, Permeability, Conductivity, Measurement, Equipment, Data processing, Regression analysis, Groundwater, Hydrology.

The objective of this study was to develop surface electrical resistivity methods for estimating hydraulic conductivities in glacial outwash materials. Aquifer electrical resistivities were determined from the results of Schlumberger electrical soundings at six sites in southern Rhode Island where pumping tests had previously been made. Hydraulic conductivities and transmissivities determined from pumping tests then were correlated with resistivities obtained from electrical soundings. Results indicated that electrical resistivities determined from soundings can be used to predict aquifer hydraulic conductivities; an empirical was developed. A semiempirical relation between aquifer formation factor and hydraulic conductivity also was developed.

77:02F-037
THE SIGNIFICANCE AND PREDICTION OF OBSERVATION WELL RESPONSE DELAY IN SEMI-CONFINED AQUIFER-TEST ANALYSIS,
Black, J.H., and Kipp, K.L., Jr.
Institute of Geological Sciences, Department of Hydrogeology, London (England).
Ground Water, Vol. 15, No. 6, p 446-451, November-December, 1977. 4 fig, 1 tab, 10 ref.

Descriptors: *Observation wells, *Water levels, *Aquifer testing, *Graphical analysis, *Curves, Aquifers, Pumping, Equations, Leakage, Aquitards, Aquicludes, Drawdown, Transmissivity, Storage coefficient, Hydraulic conductivity.

The concept of the observation well as a measuring instrument with its own response characteristics was developed, and a method for response evaluation was derived based on methods of slug-test analysis. The effect of well response time upon the results of semiconfined aquifer tests was calculated, and a series of type curves was produced. The ambiguity of observation well response affected leaky aquifer tests was demonstrated. A method for calculating well response time based on estimates of aquifer parameters and observation well dimensions also was presented to aid the proper design of aquifer tests. It was recommended that a slug test should be performed on every observation well used in confined or semiconfined aquifer tests.

77:02F-038
DETERMINATION OF TRANSPORT MODEL PARAMETERS IN GROUNDWATER AQUIFERS,
Murty, V.V.N., and Scott, V.H.
Punjab Agricultural University, Department of Soil and Water Engineering, Ludhiana, India.
Water Resources Research, Vol. 13, No. 6, p 941-947, December 1977. 1 fig, 6 tab, 20 ref. 23 equ.

Descriptors: Hydrodynamics, Groundwater, Aquifers, Model studies, Groundwater resources, Groundwater movement.

The hydrodynamic dispersion coefficients in groundwater aquifers can be determined from observed values of solute concentrations. For a two-dimensional aquifer in which the concentrations of a solute are known, an algorithm is developed to determine the values of longitudinal and transverse dispersivities. Concentration polynomials are developed by using double interpolation for a set of selected values of longitudinal and transverse dispersivities. With two of the polynomials, Newton's method is used to find the roots which are the values of the longitudinal dispersivity and the ratio of longitudinal to transverse dispersivities. With more than two polynomials an optimization approach is used in arriving at the values. The methods converge to the true values for a good initial estimate of the values.

77:02F-039
A MODIFIED OPTIMIZATION METHOD OF ESTIMATING AQUIFER PARAMETERS,
Navarro, A.
United Nations, Centre for Natural Resources, Energy, and Transport/Economic and Social Affairs Department, Water Resources Branch, New York 10017.
Water Resources Research, Vol. 13, No. 6, p 935-939, December 1977. 3 tab, 15 ref, 11 equ.

Descriptors: Optimization, Aquifers, Groundwater, Groundwater movement, Groundwater resources, Aquifer characteristics, Mathematical studies, Model studies.

A modified optimization method for estimating transmissivity and storativity parameters has been utilized for the fast calibration of mathematical models of transient aquifers. The method provides usable solutions at an intermediary point between the minimization of residuals in the water budget equations and the similitude of solutions to field estimations of parameters T and S. Four field examples of the use of the method are given and discussed in terms of relative accuracy of results.

77:02F-040
CHEMICAL DYNAMICS OF A CONFINED LIMESTONE AQUIFER,
LeFebre, V.
New Mexico Institute of Mining and Technology, Department of Physics, Socorro, New Mexico.
Available from the National Technical Information Service, Springfield, Virginia 22161 as PB-265666, Price codes: A12 in paper copy, A01 in microfiche. New Mexico Water Resources Research Institute, Las Cruces, WRRI Report No. 084, March 1977, 253 p, 16 fig, 4 tab, 6 ref, 3 append.

Descriptors: *Aquifer characteristics, *Groundwater, *Groundwater movement, *New Mexico, Saline water intrusion, Physicochemical properties, Flow characteristics, Time, Velocity, Limestone, Recharge, Dissolved oxygen, Ions, Artesian aquifers.

The evolution of groundwater in the Roswell Limestone Aquifer is measured using some ordinary and easily determined characteristics of the water. Randomness caused by analytical error and matrix inhomogeneity is suppressed by dividing the study area into subsections on the basis of hydrologic function and by using averaged values of the measured characteristics to describe each subdivision. Temperature, ionic solute concentrations, calcite saturation, and dissolved oxygen content change in a reasonably steady and monotonic manner as the water flows from the recharge to the discharge region. Simple models are developed to quantify the oxygen and temperature measurements. On the basis of these models the groundwater flow is found to be a factor of 6 faster in the northern part of the Roswell Limestone Aquifer and the residence time is a factor of 3 longer in the southern part. Solute concentrations indicate intrusion into the northeast corner of the Limestone Aquifer from an upper Alluvium Aquifer. This study demonstrates that groundwater evolves in a measurable manner as it flows through an aquifer. Both physical (temperature) and chemical (oxygen content and calcite saturation) parameters change in a predictable fashion.

77:02F-041
IRRIGATION WASTEWATER DISPOSAL WELL STUDIES--SNAKE PLAIN AQUIFER,
Graham, W.G., Clapp, D.W., and Putkey, T.A.
Idaho Department of Water Resources, Statehouse, Boise, Idaho 83720.
Publication No. EPA-600/3-77-071, June 1977. 51 p, 8 fig, 22 tab, 13 ref.

Descriptors: Runoff, Idaho, Irrigation, Irrigation effects, Aquifers, Water quality.

Drain wells are used to dispose of excess irrigation and surface runoff water from approximately 320,000 acres of agricultural land within the eastern Snake River Plain area of southern Idaho. The impact of this practice on the underlying Snake River Plain aquifer, the primary source of potable water for approximately 140,000 people, was not understood. Thus, an investigation was initiated to evaluate the impact of irrigation disposal well practices on the water quality of the Snake Plain aquifer.

77:02F-042
NEBRASKA'S GROUND WATER MANAGEMENT ACT,
Axthelm, D.D.
Nebraska University, Department of Agricultural Engineering, Lincoln, Nebraska.
Presented at the 1977 Winter Meeting of the American Society of Agricultural Engineers, December 13-16, 1977, Palmer House Hotel, Chicago, Illinois, p 1-5, 4 ref.

Descriptors: Nebraska, Groundwater, Groundwater resources, Law enforcement.

The Ground Water Management Act in Nebraska is becoming operational. It is being put into effect in a deliberate and orderly manner by the Natural Resources Districts of Nebraska as dictated by state statute.

77:02F-043
GROUNDWATER MANAGEMENT POLICIES: THE VIEWS OF THE PEOPLE,
Baird, F.L.
Texas Tech University, Department of Political Science, Lubbock, Texas.
Proceedings of the 1977 Annual Technical Conference, Irrigation For All Reasons, p 137-160, February 13-15, 1977. 1 fig, 14 tab, 29 ref.

Descriptors: Groundwater, Groundwater basins, Groundwater potential, Groundwater resources, Texas, Irrigation, Urbanization.

The primary objective of this study was to measure the attitudes toward alternative public institutions for groundwater planning and management on the Texas High Plains. More specifically, the objectives of this project were (1) To determine the attitudes of irrigation farmers in the High Plains of Texas toward various possible forms for the planning and management of groundwater, whether such regulations be individual, local, state, national or some combination of these, (2) To measure and analyze the attitudes of urban residents in a Standard Metropolitan Statistical Area (SMSA) of the region toward the same topic, and (3) To measure the attitudes of college students toward these.

77:02F-044
PRACTICAL GROUND WATER MANAGEMENT,
Axthelm, D.D.
Nebraska University, Department of Agricultural Engineering, Lincoln, Nebraska.
Proceedings of the 1977 Annual Technical Conference, Irrigation For All Reasons, p 168-172, February 13-15, 1977.

Descriptors: Groundwater, Irrigation, Groundwater resources, Groundwater recharge, Groundwater mining, Groundwater basins, Nebraska, Natural resources, Resources.

The emphasis on groundwater development for irrigation lasted about a century. Concern has now shifted from development to management of the groundwater resources. This emphasis will continue indefinitely. There is a current need to develop practical management methods and techniques.

77:02F-045
STEADY STATE BI-LEVEL SUBSURFACE DRAINAGE THEORY FOR SOILS OF VARYING HYDRAULIC CONDUCTIVITY,
Acharya, H.S.
Marathwada Agricultural University, Department of Agricultural Engineering, Parbhani (India).
Transactions of the American Society of Agricultural Engineers, Vol. 20, No. 2, p 276-277, March-April, 1977. 3 fig, 1 tab, 4 ref.

Descriptors: *Drainage, *Hydraulic conductivity, *Water table, *Model studies, Mathematical models, Tile drainage, Equations, Subsurface drainage, Groundwater, Groundwater movement, Hydrology.

In practice, various situations exist where hydraulic conductivity varies with depth. Soils with varying clay percentage, with varying stone content, or with layers of different types of soils form a few examples of such situations. The aim of this article was to study the steady-state bi-level subsurface drainage problem for soils with varying hydraulic conductivity. Cases of constant hydraulic conductivity follow as special cases of the analysis.

77:02F-046
ESTIMATION OF AQUIFER DIFFUSIVITY IN STREAM-AQUIFER SYSTEMS,
Singh, S.R., and Sagar, B.
Punjab Agricultural University, Department of Soil and Water Engineering, Ludhiana (India).
Journal of the Hydraulics Division, American Society of Civil Engineers, Vol. 103, No. HY11, Proceedings Paper 13362, p 1293-1302, November 1977. 1 fig, 2 tab, 18 ref.

Descriptors: *Diffusivity, *Aquifers, *Groundwater, *Mathematical models, *Streams, Equations, Hydrographs, Model studies, Aquifer characteristics, Water levels, Hydraulic gradient.

By specifying an extra boundary condition in terms of hydraulic gradient at the stream-aquifer interface and by using the Green's function of the linearized Boussinesq equation, analytical solutions were developed to determine aquifer diffusivity explicitly. Four different types of Dirichlet boundary condition describing stream gage hydrographs were employed. They were: (1) linearly rising water level in the stream; (2) exponentially rising water level in the stream; (3) water level represented by a sinusoid; and (4) hydrographs approximated by cubic splines. The last one is quite general and is capable of analyzing different shapes of smooth stream hydrographs expected to occur in nature. Hydraulic gradient at the interface was computed using splines. The solutions were validated by analyzing the stream-aquifer data observed in a sand tank model. They yielded consistent values of the aquifer diffusivity at different times and, therefore, are useful in determining the parameter of the aquifers contiguous to streams.

77:02F-047
UNSTEADY FLOW TO A PUMPED WELL IN A FISSURED WATER-BEARING FORMATION,
Boulton, N.S., and Streltsova, T.D.
Sheffield University, Department of Civil and Structural Engineering, (England).
Journal of Hydrology, Vol. 35, No. 3/4, p 257-269, November 1977. 9 fig, 3 ref.

Descriptors: *Unsteady flow, *Groundwater movement, *Mathematical models, *Fissures (geologic), *Water wells, Equations, Drawdown, Compressibility, Permeability, Curves, Hydraulic properties, Porosity, Aquifer characteristics, Pumping, Discharge (water), Flow.

New equations were derived for the drawdown in a water-bearing fissured rock formation, consisting of a set of horizontal low-permeability porous blocks separated by highly permeable fissures. Porous blocks and fissures were assumed to be compressible. The depth of the fissure is small compared with that of the block. The abstraction well, lined along the block, is pumped at a constant rate. The discharge per unit length of the unlined part in the fissure is constant, and the radius of the well is vanishingly small. Type curves for the drawdown in the fissure and the porous block were computed and plotted for some selected parameters involved. Procedure for determining the fissured aquifer parameter constants was outlined.

77:02F-048
UNSTEADY FLOW TO A PUMPED WELL IN A TWO-LAYERED WATER-BEARING FORMATION,
Boulton, N.S., and Streltsova, T.D.
Sheffield University, Department of Civil and Structural Engineering, (England).
Journal of Hydrology, Vol. 35, No. 3/4, p 245-256, November 1977. 5 fig, 1 ref.

Descriptors: *Unsteady flow, *Groundwater movement, *Mathematical models, *Water wells, Equations, Drawdown, Fissures (geologic), Discharge (water), Curves, Pumping, Compressibility, Hydraulic properties, Aquifer characteristics.

New equations were derived for the drawdown in an aquifer, consisting of two horizontal layers, referred to as the block and the fissure, which have different hydraulic properties. The block and the fissure are compressible. Account was taken of both the horizontal and vertical flow components in the block and the fissure. The depth of the fissure was assumed to be small compared with that of the block. The abstraction well, which is pumped at a constant rate, has a vanishingly small radius. Type curves for drawdown in the fissure and the block were computed and plotted for some values of the aquifer constants involved.

77:02F-049
THE KINETICS OF MINERAL DISSOLUTION IN CARBONATE AQUIFERS AS A TOOL FOR HYDROLOGICAL INVESTIGATIONS, II. HYDROGEOCHEMICAL MODELS,
Mercado, A.
Tahal-Water Planning for Israel Ltd., Tel Aviv.
Journal of Hydrology, Vol. 35, No. 3/4, p 365-384, November 1977. 10 fig, 13 ref.

Descriptors: *Dissolved solids, *Mineral water, *Transmissivity, *New Mexico, Model studies, Mathematical models, Aquifers, Limestones, Hydrology, Water quality, Chemicals, Water chemistry, Groundwater, Groundwater movement, Spatial distribution, Hydraulic conductivity, Permeability, Recharge, Rainfall.

A general differential equation, describing the dissolution of minerals and the transport of their products in porous media, was derived and simplified for the case of steady-state, nonequilibrium distribution of solutes in confined carbonate aquifers. The numerical solution of the equation, which represents the hydrogeochemical model of a given aquifer, was based on the transformation of aquifer space coordinates into time coordinates of "tracing points" moving along groundwater streamlines, followed by an inverse transformation which yields theoretical water quality maps. The applicability of the model for integrating hydrologic and geochemical data in aquifers was demonstrated for the limestone aquifer of Roswell, New Mexico.

77:02F-050
NONLINEAR DIFFUSION APPLIED TO GROUNDWATER CONTAMINATION PROBLEMS,
Basak, P., and Murty, V.V.N.
Punjab Agricultural University, Department of Civil Engineering, Ludhiana, India.
Journal of Hydrology, Vol. 35, No. 3/4, p 357-363, November 1977. 5 fig, 5 ref.

Descriptors: Mathematical studies, Diffusion, Groundwater, Groundwater movement, Groundwater resources, Aquifers, Water quality, Water pollution.

An analytical solution to the problem of concentration dependent diffusion with increasing concentration at the source is presented. The solution is of traveling wave type and is applied to predict the contamination in an aquifer from a source wherein the contamination concentration is increasing with time.

77:02F-051
PUMP TESTING IN HETEROGENEOUS AQUIFERS,
Vandenberg, A.
Inland Waters Directorate, Environment Canada, Ottawa, Ontario, Canada.
Journal of Hydrology, Vol. 34, No. 1/2, p 45-62, July 1977. 12 fig, 1 tab, 11 ref.

Descriptors: Model studies, Aquifers, Groundwater, Groundwater resources, Simulation analysis, Pump testing, Pumping plants, Pumps, Transmissivity.

A finite-difference model of an infinite horizontal nonleaky aquifer was used to simulate a constant-rate pump test in a heterogeneous aquifer; the values of transmissivity specified for the nodes of the finite-difference grid were chosen at random from a uniform distribution over the interval 0-0.1 m sq/min and the ratio transmissivity/storativity was kept constant. The spacing of the finite-difference grid was 10 m in the vicinity of the pumped well at the center of the grid and became progressively wider towards the boundaries of the square area. The boundaries were located at a distance of 23 km from the well.

77:02F-052
NON-DARCY FLOW AND ITS IMPLICATIONS TO SEEPAGE PROBLEMS,
Basak, P.
Punjab Agricultural University, Department of Civil Engineering, Luhiana (India).
Journal of the Irrigation and Drainage Division, American Society of Civil Engineers, Vol. 103, No. IR4, Proceedings Paper 13442, p 459-473, December 1977.
9 fig, 4 tab, 44 ref.

Descriptors: *Drainage, *Seepage, *Darcys law, Drainage systems, Porous media, Confined water, Analytical techniques, Hydraulics, Equations, Flow, Discharge (water).

Analytical solutions for the problems of drainage spacing in a ditch drainage system and steady-state seepage through confined aquifer of variable thickness incorporating Izbash's nonlinear velocity-gradient response v = M times i to the nth power were presented. The effect on nonlinearity in the flow response on the drainage spacing, discharge characteristics, and piezometric pressure distribution in relation to the corresponding Darcian linear case was brought out. The solutions derived showed that nonrecognition of even a weak non-Darcy flow would lead either to an uneconomical or an unsafe (depending on the value of non-Darcy parameter n) drainage spacing for ditch drainage problems and would lead to considerable over or under prediction of discharge for confined aquifer problem. Apart from the previously mentioned analytical solutions, a perspective view of non-Darcy flow through porous media was incorporated, and its importance in various drainage projects was examined.

SECTION VI

WATER CYCLE

WATER IN SOILS (GROUP O2G)

77:O2G-001
A COMPARISON OF IN SITU EXTRACTORS FOR SAMPLING SOIL WATER,
Levin, M.J., and Jackson, D.R.
Oak Ridge National Laboratory, Environmental Sciences Division, Tennessee.
Soil Science Society of America Journal, Vol. 41, No. 3, p 535-536, May-June,
1977. 1 fig, 1 tab, 3 ref.

Descriptors: *Soil water, *Sampling, *Aqueous solutions, Solvents, Lysimeters, Tensiometers, Laboratory tests, Evaluation, Equipment, Leaching, Leachate, Soil science.

Comparisons were made between two in situ extractors for collection of soil water samples: Amicon hollow fibers and porous ceramic cup lysimeters. Intact soil cores removed from a fescue pasture were fitted with lysimeters and fibers at 10 and 20 cm depth. Cores were leached by adding increments of water in excess of field capacity weekly. After drainage, soil solutions were extracted using lysimeters and fibers. Concentrations of Ca and Mg in soil solutions were greater at 10-cm than at 20-cm soil depths. Neither extractor altered the concentrations of Ca, Mg, or PO4-P during collection. The studies suggest that lysimeters and hollow fibers are viable devices for extracting of soil water samples. Porous ceramic cup lysimeters are preferable for field plots, while hollow fibers are advantageous for intact soil cores. A major advantage of the hollow fiber technique is the small soil displacement required for installation.

77:O2G-002
EXPERIMENTAL STUDIES OF WETTING FRONT INSTABILITY INDUCED BY GRADUAL CHANGE OF PRESSURE GRADIENT AND BY HETEROGENEOUS POROUS MEDIA,
White, I., Colombera, P.M., and Philip, J.R.
Commonwealth Scientific and Industrial Research Organization, Division of Environmental Mechanics, Canberra (Australia).
Soil Science Society of America Journal, Vol. 41, No. 3, p 483-489, May-June,
1977. 7 fig, 3 tab, 15 ref.

Descriptors: *Infiltration, *Porous media, *Laboratory tests, Soil water, Soil water movement, Model studies, Mathematical models, Soils, Pressure, Hydraulic conductivity, Soil science, Soil physics.

The stability of infiltration flows in Hele-Shaw cells was examined. Flows were perturbed either by gradually increasing G, the pressure gradient behind the wetting front, or by heterogeneities in the cells. Two methods were used to increase G gradually through zero: (1) by allowing the air ahead of the front to be compressed by the flow, and (2) by monotonically increasing the hydraulic conductivity of the cell with depth. In the other class of experiments, the flow was instantaneously perturbed by a step-increase in conductivity at selected depths. It was found that Philip's stability analysis adequately predicted both the onset of instability and the wavelength of the initial disturbances. For quadratic increase in conductivity with depth, the observed growth rate of disturbances was faster than expected from the linear theory. Examination of the data of Peck and of Hill and Parlange showed that Philip's analysis is also adequate for coarse sands.

77:O2G-003
MODEL CALCULATIONS FOR THE EXTRACTION OF SOIL WATER BY CERAMIC CUPS AND PLATES,
van der Ploeg, R.R., and Beese, F.
Institute of Soil Science and Forest Nutrition, Goettingen (West Germany).

Soil Science Society of America Journal, Vol. 41, No. 3, p 466-470, May-June, 1977. 5 fig, 2 tab, 20 ref.

Descriptors: *Soil water, *Soil water movement, *On-site investigations, Percolation, Unsaturated flow, Seepage, Sampling, Soil moisture, Model studies, Mathematical models, Soils, Soil science, Soil physics.

A numerical method was developed with which the flow of moisture towards suction units in soil can be evaluated. For a number of selected problems, the unsaturated moisture flow equation was solved twice: (1) for radial flow towards a suction plate or suction cup; and (2) for vertical downwards flow under the same conditions, but without a suction unit in the soil. The calculations were performed for a flat soil without a plant cover. It was found that even for little vacuum, large differences may exist between the seepage rate as determined from a suction unit as compared to the seepage rate of the unextracted soil. It was shown also that the radius of influence of a suction unit, which extracts water continuously, can be several feet wide. It was concluded that in order to be reliable, data collected with suction units should be analyzed with care.

77:02G-004
WATER AND SALT FLOW THROUGH COMPACTED CLAYS: I. PERMEABILITY OF COMPACTED ILLITE AND MONTMORILLONITE,
Rolfe, P.F., and Aylmore, L.A.G.
Western Australia University, Extension Service, Nedlands.
Soil Science Society of America Journal, Vol. 41, No. 3, p 489-495, May-June, 1977. 4 fig, 3 tab, 47 ref.

Descriptors: *Permeability, *Clays, *Salts, Laboratory tests, Montmorillonite, Illite, Chlorides, Cations, Pressure, Soil water movement, Solutions, Sodium chloride, Cesium, Calcium chloride, Chemistry, Soil water, Soil science.

Studies have been made of the pressure-induced flow of the chloride solutions of various monovalent, divalent and trivalent cations, at various concentrations, through compressed Wyoming bentonite and Willalooka illite cores. The majority of the measurements were carried out on the Willalooka illite core, and its permeability has been shown to depend markedly on the nature and concentration of the cations present, with three- to fourfold variations being observed in some instances. At the lower electrolyte concentrations, permeability increases in the order Na less than Ca less than Ba less than La less than Cs at a given concentration. In addition, the permeability increases linearly with flow pressure to an extent ranging from some 15% for the Na systems to 97% for the 3.0 M LaCl3 system over the pressure range examined. The contributions to the permeability changes arising from mechanical expansion of the flow cell, particle rearrangements and the electroviscous effect have been shown to be quite inadequate to account for the major changes observed. It was suggested that the most significant effects arise as a result of the influence of cationic size, charge, and concentration of the vicosity of the several layers of coerced water which form adjacent to the clay surfaces. Coercion of water may arise partly through its association with the exchangeable cations adsorbed on the surface or forming diffuse double layers, but mainly from the preferred or unique water structure developed in proximity to the clay surface. In particular, increasing concentrations of Cs, Ca and La cations appear to cause a pronounced breakdown in water structure within the pores.

77:02G-005
FALL SOIL WATER: EFFECT ON SUMMER SOIL TEMPERATURE,
Willis, W.O., Wierenga, P.J., and Vredenburg, R.T.
Agricultural Research Service, Fort Collins, Colorado.
Soil Science Society of America Journal, Vol. 41, No. 3, p 615-617, May-June, 1977. 5 fig, 10 ref.

Descriptors: *Soil temperature, *Soil water, *Effects, *North Dakota, Soil moisture, Crops, Wheat, On-site investigations, Model studies, Mathematical models, Forecasting, Analytical techniques, Soil properties, Thermal properties, Soil-water-plant relationships, Soil investigations, Soil science, Agriculture.

Soil temperature with depth (to 150-cm) and time (April through September) was measured in field plots in North Dakota to determine the effect of three depths of wetting in late fall before freezing on the growing season soil temperature the following year. All plots were planted with spring wheat and received identical treatment during the growing season. The data indicated that a high soil water content in the fall may cause soil temperature in the 30- to 120-cm depth to be 1 to 2 C lower than normal during the next year's growing season, particularly if that season has lower-than-normal precipitation. By using soil temperature values from the 15-cm and 120-cm depths as the upper and lower boundaries, calculated soil temperatures agreed better with measured values than when 0.2-cm and 120-cm depths were used as boundaries.

77:02G-006
EVALUATION OF THEORETICALLY PREDICTED THERMAL CONDUCTIVITIES OF SOILS UNDER FIELD AND LABORATORY CONDITIONS,
Hadas, A.
Agricultural Research Organization, Institute of Soil and Water, Bet-Dagan (Israel).
Soil Science Society of America Journal, Vol. 41, No. 3, p 460-466, May-June, 1977. 7 fig, 18 ref.

Descriptors: *Soil water movement, *Heat transfer, *Water vapor, Soil moisture, Soil water, Soil temperature, Irrigation, Irrigation effects, Thermal conductivity, Model studies, On-site investigations, Laboratory tests, Soil physics, Agriculture, Soil science.

In the literature one finds claims that the Philip-deVries model of heat and moisture transfer fails to predict the amounts of water moved by vapor transfer. In the work reported here, an attempt was made to check and to verify the predictive capabilities of the deVries, Philip and deVries models for vapor transfer by evaluating the latent heat transfer carried by vapor rather than to account for vapor flow from the usually performed total moisture balance. It was found that the deVries model predicts accurately the transfer of heat by vapor under steady-state conditions, but the model underestimates transfer of heat under nonsteady-state conditions. The possibility that the assumed diffusive vapor transport should be corrected by including "enhancement factors" so as to incorporate local thermal gradients and mass movement induced vapor transfer, not accounted by the present model, was brought up; and the nature of the enhancement factors and the implications to field conditions were discussed.

77:02G-007
DIURNAL SOIL WATER REGIME IN THE TILLED PLOW LAYER OF A WARM, HUMID CLIMATE,
Bruce, R.R., Thomas, A.W., Harper, L.A., and Leonard, R.A.
Southern Piedmont Conservation Research Center, Watkinsville, Georgia.
Soil Science Society of America Journal, Vol. 41, No. 3, p 455-460, May-June, 1977. 12 fig, 1 tab, 14 ref.

Descriptors: *Soil water, *Diurnal, *Cultivation, *Humid climates, Depth, Soil temperature, Air temperature, Wind velocity, Vapor pressure, Water vapor, On-site investigations, Humid areas.

The soil water content in 10 depth intervals in the surface 15 cm of soil was determined hourly for 9 days in June at 83 deg 25 min W, 33 deg 52 min N. Over the same period at 15-min intervals, soil temperatures were measured at eight depths, wind-speed and air temperatures at six elevations, atmospheric water vapor pressures at three elevations, incident solar and net radiation at one meter. From the microclimate data, flux of water vapor at the soil surface was calculated, which was then used to compute soil water flux at several depths by using soil water content data. The diurnal soil water content and soil water flux patterns were compared for a dry period before a rainfall event and afterward. Dramatic diurnal variation of the soil water content at depths less than 2 cm was observed. The variation during periods of no rain is related to daily radiation inputs at the soil surface, which generated the observed temperature and soil water gradients responsible for soil water redistribution. Occurrence of rainfall and infiltration events during the measurement period showed additional dynamics of the field system. Descriptions of the diurnal soil water dynamics in the plow-layer provide a basis for examining soil processes dependent upon soil water regime.

77:02G-008

AUTOMATIC FEEDBACK CONTROL TO MAINTAIN CONSTANT SOIL MOISTURE TENSION IN THE STUDY OF DROUGHT TOLERANCE IN RICE,

Alvarez, E.I., and De Datta, S.K.
International Rice Research Institute, Department of Agronomy, Los Banos, Laguna (Philippines).
Soil Science Society of America Journal, Vol. 41, No. 3, p 452-454, May-June, 1977. 3 fig, 2 tab, 9 ref.

Descriptors: *Moisture tension, *Soil moisture, *Rice, *Soil-water-plant relationships, Greenhouses, Evapotranspiration, Laboratory equipment, Moisture stress, Perlite, Osmotic pressure, Tensiometers, Analytical techniques.

A greenhouse technique was developed by which a chosen soil moisture tension can be maintained continuously. The setup for supply water at relatively constant soil moisture tension in pots includes five major components: water tank, W-tube, water distribution system, soil moisture tension sensors, and pots. The W-tube, which contains a predetermined amount of Hg, controls the soil moisture tension in the pots. Water can flow freely from the tank to the pots through the distribution system whenever the soil moisture tension exceeds that desired. Response to the sensors' demand for water is rapid. This setup was used successfully to compare relative drought tolerance of rice varieties and breeding lines. Another use of the setup might be to measure evapotranspiration (ET) almost instantaneously; the technique might be useful in some soil-plant-atmosphere-water relationship studies.

77:02G-009

EXPERIMENTAL TEST OF THE LANGEVIN EQUATION AS A MODEL FOR WATER FLOW THROUGH UNSATURATED SOIL,

Sposito, G., Sullivan, P., and Gupta, V.
California University, Department of Soil Science and Agricultural Engineering, Riverside, California.
Soil Science Society of America Journal, Vol. 41, p 820-822, 1977. 2 fig, 19 ref, 8 equ.

Descriptors: *Model studies, *Unsaturated flow, *Soil water movement, *Hydraulic conductivity, *Diffusivity, Equations, Soil moisture.

The parameters that appear in the Langevin Equation, a molecular model for the flow of water through soil, are expressed as functions of the hydraulic conductivity, the water diffusivity, and the soil water matric potential. This permits the parameters to be calculated using available data on the transport properties of homogeneous, unsaturated soils. Since the parameters must have values lying within certain ranges in order that the Langevin Equation and the Markovian hypothesis on water flow that comes from it be applicable, it is possible to test the equation and the hypothesis experimentally. The results for 15 different soils shows that: (1) the equation and the Markovian hypothesis are consistent with soil water data for homogeneous, unsaturated soils throughout the normal field range of water content and (2) the molecular parameters in the Langevin Equation show the same behavior for a wide variety of soils when they are expressed as functions of the matric potential.

77:02G-010

INFLUENCE OF SOIL PROPERTIES, LEACHING FRACTION, AND PLANT WATER UPTAKE ON SOLUTE CONCENTRATION DISTRIBUTION,

Jury, W.A., Fluhler, H., and Stolzy, L.H.
California University, Department of Soil Science and Agricultural Engineering, Riverside, California.
Water Resources Research, Vol. 13, No. 3, p 645-650, June 1977. 9 fig, 1 tab, 19 ref.

Descriptors: *Leaching, *Soil water movement, *Soil properties, *Laboratory tests, Moisture content, Lysimeters, Solutes, Soil water, Water quality, Soil moisture, Model studies, Mathematical models, Simulation analysis, Profiles, Distribution patterns, Soils, Hydraulic conductivity, Clay loam, Loam, Water balance.

Studies of salt movement through 24 cropped lysimeters receiving high-salinity irrigation were reported. A great deal of variability was found between depth-equivalent salinity sensor readings during the experiment, both between different lysimeters receiving the same water and salt inputs and among lateral replicates within each lysimeter. A computer simulation of the first 75 days of the experiment, using the measured soil properties and external inputs, alternately varied the hydraulic conductivity-water content relation, the irrigation flux, and the water uptake distribution by an amount consistent with the uncertainty in their measurement to see the effect on solute concentrations. It was found that large variations in the conductivity-water content relations and 10% uncertainty in the input flux had little effect on solute concentrations, but that variations in the water uptake patterns within the top 60 cm created a large distribution of concentrations at a given depth and time.

77:O2G-011
ESTIMATING THE EFFECTIVE CAPILLARY PRESSURE IN THE GREEN AND AMPT INFILTRATION EQUATION,
Brakensiek, D.L.
Agricultural Research Service, Northwest Watershed Research Center, Boise, Idaho.
Water Resources Research, Vol. 13, No. 3, p 680-682, June 1977. 1 fig, 1 tab, 7 ref.

Descriptors: *Infiltration, *Mathematical models, *Pore pressure, *Capillary water, Capillary conductivity, Model studies, Loam, Moisture content, Soils, Pressure, Groundwater movement, Wetting, Estimating.

A considerable amount of research indicates that the Green and Ampt infiltration equation can be used in hydrologic modeling with confidence. The parameters, however, still require considerable field and/or laboratory effort to determine estimated values. Reported were alternatives for determining the average wetting front capillary pressure parameter. Only a moisture-characteristic would be required.

77:O2G-012
MASS TRANSFER STUDIES IN SORBIN POROUS MEDIA: II. EXPERIMENTAL EVALUATION WITH TRITIUM (3H20),
van Genuchten, M.T., and Wierenga, P.J.
New Mexico State University, Department of Agronomy, University Park, New Mexico.
Soil Science Society of America Journal, Vol. 41, No. 2, p 272-278, March-April, 1977. 6 fig, 3 tab, 21 ref, 1 append.

Descriptors: *Tritium, *Mass transfer, *Porous media, *Sorption, Diffusion, Curves, Adsorption, Soil aggregates, Unsaturated flow, Mathematical models, Clay loam, Laboratory tests, Equations.

A comparison was made between observed tritium effluent concentration distributions and those calculated with a previously published analytical solution for the movement of chemicals through unsaturated, aggregated sorbin media. In the analytical model, the liquid phase of the soil was divided into mobile and immobile regions, with transfer between the two regions diffusion controlled. Effluent data obtained from several displacements of tritium through a 30-cm long columns of Glendale clay loam were used to determine the different parameters in the analytical solution by curve fitting. The data indicated some adsorption or isotopic exchange of tritium during its flow through the soil columns. The amount of immobile water increases with decreasing flow velocity and increasing aggregate size, and varies between 6 and 45% of the total volume of water in the columns. The analytical solution provided an excellent description of the experimental effluent data, and showed that tailing can be explained satisfactorily by diffusional exchange of tritium between mobile and immobile regions of the soil.

77:O2G-013
MASS TRANSFER STUDIES IN SORBING POROUS MEDIA: III. EXPERIMENTAL EVALUATION WITH 2, 4, 5-T,
van Genuchten, M.T., Wierenga, P.J., and O'Connor, G.A.
New Mexico State University, Department of Agronomy, University Park, New Mexico.
Soil Science Society of America Journal, Vol. 41, No. 2, p 278-285, March-April, 1977. 6 fig, 3 tab, 16 ref,

Descriptors: *Mass transfer, *Sorption, *Porous media, Diffusion, Adsorption, Unsaturated flow, Hysteresis, Soil aggregates, Clay loam, Laboratory tests, Curves, Mathematical models.

Comparisons were made between observed and calculated effluent concentration distribution for the movement of 2, 4, 5-T (2,4,5-trichlorophenoxyacetic acid) through 30-cm long unsaturated soil columns. The comparisons were made using both analytical and numerical solutions of a previously published model, which included the effects of intra-aggregate diffusion and adsorption. The results in this study indicated that intra-aggregate diffusion and adsorption/desorption are the main mechanisms responsible for effluent tailing. An estimated 60% of the adsorption was found to occur in the stagnant region of the soil. When intra-aggregate diffusion was included in the model, the observed adsorption/desorption hysteresis phenomenon found to be significant in several earlier studies was shown to be much less important in describing the observed concentration distributions.

77:02G-014
MODELING SOIL WATER HYDROLOGY UNDER A POST OAK (QUERCUS STELLATA WANGENH) - SHORTLEAF PINE (PINUS ECHINATA MILL.) STAND IN EAST TEXAS,
England, C.B.
Agricultural Research Center, Hydrograph Laboratory, Beltsville, Maryland.
Water Resources Research, Vol. 13, No. 3, p 683-686, June 1977. 3 fig, 1 tab, 20 ref.

Descriptors: *Soil water, *Model studies, *Forest watersheds, *Texas, Computer models, Mathematical models, Soil water movement, Oak trees, Pine trees, Hydrology, Hydrologic aspects, Hydrologic systems, Infiltration, Evapotranspiration, Watersheds (basins), On-site investigations.

A digital model of watershed hydrology successfully computed daily soil water contents of the two upper layers in a Boswell soil under an east Texas post oak - shortleaf pine stand throughout 4 years (1957-1960). The experiment demonstrated the fidelity of the model components to the prototype system elements. In addition, the experiment provided parameters useful in applying the model for elucidating the hydrology of watersheds containing oak-pine forests.

77:02G-015
MODEL OF SALT FLOW IN SOIL WITH A SOURCE-SINK TERM,
Melamed, D., Hanks, R.J., and Willardson, L.S.
Utah State University, Department of Soil Science, Logan, Utah.
Soil Science Society of America Journal, Vol. 41, No. 1, p 29-33, January-February, 1977. 4 fig, 12 ref.

Descriptors: *Saline soils, *Irrigation, *Salts, *Model studies, Mathematical models, Laboratory tests, On-site investigations, Soil properties, Salinity, Electrical conductance, Conductivity, Soil chemical properties, Effluents, Chemical precipitation, Leaching, Soil science, Path of pollutants.

Irrigation management practices require a knowledge of the salinity in the root zone. Models which simulate the simultaneous movement of water and soils but ignore the buffering property of the soil fail to predict the root zone salinity distribution in many field situations. A model was developed that takes into consideration source and sink processes. It was tested under laboratory and field situations. In determining a "source-sink" term to be included in the model, it was assumed that precipitation and dissolution were the most important source processes and that the rate of the processes was a function of the surrounding concentration. The parameters for the "sink-source" term for soil columns were determined from effluent data and were found suitable for predicting the salinity of the entire soil column. Under field conditions, individual parameters for each layer were needed for good prediction.

77:02G-016
FRITTED GLASS BEAD MATERIALS AS TENSIOMETERS AND TENSION PLATES,
Chow, T.L.
Newfoundland Forest Research Centre, St. John's, Newfoundland.

Soil Science Society of America Journal, Vol. 41, No. 1, p 19-22, January-February, 1977. 1 fig, 3 tab, 5 ref.

Descriptors: *Tensiometers, *Moisture tension, *Instrumentation, Materials, Porous media, Particle size, Hydraulic conductivity, Saturated flow, Laboratory tests, Materials testing, Materials engineering, Soil water, Soil science.

A maximum temperature of 655 C, which was reached in six steps with approximately 100 C/step/hour for 90 min. was used to frit glass beads. Tensiometer or tension plate with desired dimension and operational characteristics can be constructed from the product. Uniformity tests on the product indicate negligible horizontal temperature variations during the fritting process, and slow heat dissipation during the cooling phase tends to limit its thickness. Tests on the particle size distributions suggest that glass beads graded to a very narrow distribution are required to produce fritted material with both the maximum saturated hydraulic conductivity and maximum air-entry value.

77:02G-017
PREDICTIONS OF THE SOIL WATER FLUX BASED UPON FIELD-MEASURED SOIL-WATER PROPERTIES,
Warrick, A.W., Mullen, G.J., and Nielsen, D.R.
Arizona University, Tucson, Arizona.
Soil Science Society of America Journal, Vol. 41, No. 1, p 14-19, January-February, 1977. 5 fig, 4 tab, 12 ref.

Descriptors: *Soil water movement, *Variability, *Soil properties, Soil water, On-site investigations, Sampling, Hydraulic conductivity, Mathematical models, Spatial distribution, Moisture content, Soils, Clay loam, Monte Carlo method, Infiltration, Soil science.

Predictions of soil water flux are made taking into account spatial variability of the soil water parameters. A conductivity of the form K = K sub 0 exp (alpha (theta-theta sub 0)) is utilized where theta is the volumetric water content with K sub 0 and theta sub 0 the values of hydraulic conductivity and water content for steady-state intake from water ponded on the soil surface. The value of alpha is an empirical constant for each site and for each depth. Monte Carlo simulations were used to simulate the flux distribution from the simplified drainage equation J sub L = K sub 0/(1 + alpha K sub 0 t/L). The flux of J sub L is a random output dependent upon the stochastic nature of K sub 0 and alpha. Log-normal distributions of K sub 0 and alpha are chosen from field data published for Panoche soil. Output of J sub L is approximately log-normal for all times studied. The mean value of J sub L in larger than the flux calculated using the average K sub 0 and alpha values in the above equation. Sample numbers necessary to estimate the means of the flux at t = 0, 1, and 10 days were plotted. For t = 0, samples of 1,000, 100, and 50 result in estimates of J sub L within 16, 50, and 60% of the true mean 95% of the time. For t = 1 and 10 days similar figures for samples of 1,000, 100, and 50 are 4, 14, and 20%. Values of water content stored in the profile using the above equations also were examined as a random function. Unlike the flux values, the range in values stays about the same for at least 20 days. The research points out a need for meaningful methods for sample stratification in order to reduce variances.

77:02G-018
SOLUTE MOVEMENT IN A FIELD SOIL,
Van De Pol, R.M., Wierenga, P.J., and Nielsen, D.R.
New Mexico State University, Department of Agronomy, Las Cruces, New Mexico.
Soil Science Society of America Journal, Vol. 41, No. 1, p 10-13, January-February, 1977. 5 fig, 8 ref.

Descriptors: *Soil water movement, *Solutes, *Subsurface flow, On-site investigations, Soils, Porous media, Infiltration, Adsorption, Leaching, Dispersion, Variability, Spatial distribution, Tracers, Tritium, Chlorides, Pore water, Soil water, Agriculture, Soil science, Path of pollutants.

Solute and water movement was studied under steady-state flow conditions in a field soil consisting of 70 cm of clay to silty clay over a medium sand. A steady-state water flow condition was maintained by applying irrigation water at a constant flux of 2 cm per day. During the steady-state conditions, some of the water leached into the plot was labelled with chloride and tritium. The positions of the chloride and tritium as functions of soil depth and time were measured by extracting samples of the soil solution with soil suction probes. Extremes in solute displacement occurred at equal and different depths within the plot. An analysis of these measurements indicated that observations of the pore water velocity and the apparent diffusion coefficient were log normally distributed. Twenty-four soil suction probes, used to identify the rate at which a solute was displaced in the soil, will yield an estimate of the mean pore water velocity of this soil within a range of approximately plus or minus 25% of its true value, providing that the effects of potential solute-soil interactions are taken into account.

77:02G-019

ON SOLVING THE NONLINEAR DIFFUSION EQUATION: A COMPARISON OF PERTURBATION, ITERATIVE, AND OPTIMAL TECHNIQUES FOR AN ARBITRARY DIFFUSIVITY,

Parlange, J.Y., and Babu, D.K.
Connecticut Agricultural Experiment Station, New Haven, Connecticut.
Water Resources Research, Vol. 13, No. 1, p 213-214, February 1977. 9 ref.

Descriptors: *Soil water movement, *Filtration, *Diffusion, *Diffusivity, Mathematical models, Equations, Mathematics, Analytical techniques, Soil water, Optimization.

A recent solution determined by Babu for an arbitrary soil-water diffusivity was compared with two earlier solutions. It was shown that the perturbation solution is identical to the iterative result when Cister's correction is used. It was also shown that a result obtained by optimization, which is numerically indistinguishable from either the perturbation or iterative result, has a much simpler analytical form.

77:02G-020

SOIL WATER REGIMES NEAR POROUS CUP WATER SAMPLERS,

Warrick, A.W., and Amoozegar-Fard, A.
Arizona University, Department of Soils, Water, and Engineering, Tucson, Arizona.
Water Resources Research, Vol. 13, No. 1, p 203-207, February 1977. 4 fig, 1 tab, 14 ref, 1 append.

Descriptors: *Soil water movement, *Unsaturated flow, *Mathematical studies, Soil water, Equations.

Steady soil water regimes near a porous cup water sampler were studied. Results are applicable when one is sampling soil solutions in the field or laboratory, and they help establish guidelines with respect to the sampling volume and region of influence. The unsaturated hydraulic conductivity is taken as K = (K sub o) exp (alpha x h), where K sub o and alpha are constants. The flow net was examined for both point and horizontal line sinks for an infinite medium around the cup. Analytical solutions for the potential and the stream functions were given for the point sink. The maximum radial distance for which flow can be intercepted is the square root of (q/pi x K sub o) exp (-alpha x h sub 1), where h sub 1 is the pressure head at large distances and q the extraction rate. An alternative form was found by expressing q in terms of the cup radius and tension. For the line sink, an analytical solution was given for the potential, but the stream function required a numerical integration. The maximum distance of influence is (q/2 K sub o) exp (-a x h sub 1), where q is the flow rate per unit length. For both point and line sinks, q increases with h sub 1. Also, q at first increases with the suction in the cup (-h sub o), but it approaches a constant value.

77:02G-021

CONVECTIVE-DISPERSIVE SOLUTE TRANSPORT WITH A COMBINED EQUILIBRIUM AND KINETIC ADSORPTION MODEL,

Cameron, D.R., and Klute, A.
Soil Research Institute, Department of Agriculture, Edmonton (Alberta), Canada.
Water Resources Research, Vol. 13, No. 1, p 183-188, February 1977. 6 fig, 1 tab, 20 ref.

Descriptors: *Soil water movement, *Mathematical models, *Adsorption, *Solutes, Equations, Analytical techniques, Theoretical analysis, Soils, Seepage, Transfer.

A given chemical may react at different rates with various soil constituents, and the chemical may be involved in several kinds of reactions. A combination of equilibrium and kinetic adsorption models was hypothesized to describe the nature of the overall reaction. An analytical solution to the one-dimensional convective-dispersive transport equation with a combination linear Freundlich isotherm and first-order reversible kinetic adsorption model was developed. The individual and combined effects of the model parameters on the breakthrough curves and retention profiles were examined. The combination equilibrium-kinetic model was shown to be applicable to pesticide, nutrient, and metal transport in soils.

77:02G-022
TRANSPORT OF REACTIVE SOLUTES THROUGH MULTILAYERED SOILS,
Selim, H.M., Davidson, J.M., and Rao, P.S.C.
Florida University, Department of Soil Science, Gainesville, Florida.
Soil Science Society of America Journal, Vol. 41, No. 1, p 3-10, January-February, 1977. 15 fig, 2 tab, 18 ref.

Descriptors: *Soil water movement, *Solutes, *Adsorption, Soil water, Saturated flow, Unsaturated flow, Soils, Sands, Loam, Laboratory tests, Mathematical models, Dispersion, Effluents, Sorption, Agriculture, Soil science, Path of pollutants.

Solute transport through saturated and unsaturated multilayered soils was studied using laboratory experiments and finite difference approximations of the solute transport equation. Soil water and physical characteristics as well as solute sorption properties were measured and/or calculated for each soil layer. Linear and nonlinear equilibrium and kinetic adsorption processes were used to predict adsorption in each layer. Water flux was assumed constant for water-saturated and unsaturated layered soil profiles. For all adsorption processes considered, the calculated results showed that the order in which the soil layers were stratified in a water-saturated profile did not influence the effluent solute concentration distribution. For unsaturated layered soil profiles, the results showed that effluent solute distributions can be predicted with an average water content within individual soil layers. Experimental results from the miscible displacement of 36Cl and 14C-labeled 2,4-D ((2,4-dichlorophenoxy) acetic acid), through a two-layered soil column supported the calculated results.

77:02G-023
WATER MOVEMENT THROUGH PEDAL SOILS: I. SATURATED FLOW,
Anderson, J.L., and Bouma, J.
Wisconsin University, Department of Soil Science, Madison, Wisconsin.
Soil Science Society of America Journal, Vol. 41, No. 2, p 413-418, March-April, 1977. 4 fig, 4 tab, 24 ref.

Descriptors: *Soil water movement, *Saturated flow, *Clay loam, Hydraulic conductivity, Dispersion, Soils, Laboratory tests, Tracers, Chlorides, Soil structure, Groundwater, Groundwater movement, Hydrodynamics, Soil science.

Apparent dispersion coefficients were determined with a chloride tracer in 55-cm long undisturbed columns from four pedal soil horizons of three pedons. Five medium subangular blocky structures were compared with five coarse prismatic structures, all with a silty clay loam texture. Dispersion coefficients (D), which could not always be calculated due to "nonideal" behavior to the flow system, were significantly different for the two types of structures. Application of an unlimited quantity of traced water to drained columns resulted in very high dispersion, particularly for the subangular blocky structures. Some practical implications of the occurrence of hydrodynamic dispersion were discussed.

77:02G-024
WATER MOVEMENT THROUGH PEDAL SOILS II. UNSATURATED FLOW,
Anderson, J.L., and Bouma, J.
Wisconsin University, Department of Soil Science, Madison, Wisconsin.
Soil Science Society of America Journal, Vol. 14, No. 2, p 419-423, March-April, 1977. 6 fig, 4 tab, 7 ref.

Descriptors: *Soil water movement, *Unsaturated flow, *Clay loam, Hydraulic conductivity, Dispersion, Soils, Laboratory tests, Tracers, Chlorides, Soil structure, Groundwater, Groundwater movement, Hydrodynamics, Soil science.

Very high hydrodynamic dispersion, occurring during application of an unlimited dose of chloride-traced water to 10 drained 55-cm long columns with undisturbed pedal soils, was strongly reduced by a daily application of 1 cm of water. Dispersion in five columns with subangular blocky structures remained significantly higher than that measured in five columns with prismatic structures. Differences were explained by a hypothetical analysis of flow patterns in both types of structure. Application of a surface crust strongly reduced dispersion in the subangular blocky structures, even though the flow rate remained approximately 1 cm/day. This was attributed to lack of flow into the larger vertical pores extending through the columns. Pronounced differences in terms of hydrodynamic dispersion were found between two types of structures from three soil series, all with a silty clay loam texture, thereby demonstrating the potential usefulness of routine soil structure descriptions as a correlative tool for predicting certain aspects of physical behavior.

77:02G-025
CONTRIBUTION OF LATERAL SOIL WATER MOVEMENT ABOVE A FRAGIPAN TO STREAMFLOW,
Palkovics, W.E., and Petersen, G.W.
Delaware Valley College of Science and Agriculture, Department of Agronomy, Doylestown, Pennsylvania.
Soil Science Society of America Journal, Vol. 41, No. 2, p 394-400, March-April, 1977. 7 fig, 2 tab, 31 ref.

Descriptors: *Soil water movement, *Streamflow, *Perched water, Groundwater, Groundwater movement, Subsurface waters, Base flow, Streams, Wells, Observation wells, Drainage, Hydraulic conductivity, Water balance, Water table, Hydrology.

A water balance approach to the hydrologic budget on a small mountainous watershed in central Pennsylvania was used to determine if lateral water flow perched above a soil fragipan could be quantitatively related to streamflow. Perched water table fluctuations were measured using a grid of 60 observation wells, and streamflow was recorded using a weir. The site was monitored in mid-November when evapotranspiration was at a minimum and when no precipitation was recorded. Soil water yield due to perched water table decline was calculated, hydraulic conductivity and the rate of water movement through the soil computed, and the zone of water contribution to streamflow determined. Results indicated that water yield from the soil aquifer explained streamflow. Saturated water flow was shown to be the main mechanism of water movement, although unsaturated flow may have been significant for short distances under low tensions. The major zone of soil water contribution to streamflow was the more poorly drained soils adjacent to the stream. Unsaturated soils on the upper mountain flanks had little effect upon streamflow because of low gradient and large distance from the stream.

77:02G-026
LATERALLY CONFINED, STEADY FLOWS OF WATER FROM SOURCES AND TO SINKS IN UNSATURATED SOILS,
Raats, P.A.C.
Agricultural Research Service, Salinity Laboratory, Riverside, California.
Soil Science Society of America Journal, Vol. 41, No. 2, p 294-304, March-April, 1977. 8 fig, 36 ref.

Descriptors: *Soil water movement, *Irrigation, *Model studies, Mathematical models, Soils, Unsaturated flow, Subsurface irrigation, Equations, Agriculture.

The application of water along lines and at points is of interest in connection with furrow, subsurface, and drip irrigation. The removal of water along lines and at points is of interest in connection with uptake of water by plant roots and a variety of devices used to extract water and measure fluxes in the laboratory and in the field. Laterally confined, steady flows from line and point sources at arbitrary distances below the soil surface and to line and point sinks at arbitrary distances above an impermeable base were analyzed on the basis of the assumption that the hydraulic conductivity is an exponential function of the pressure head. The results included expressions describing the flow pattern, the distribution of the components of the flux, and the distributions of matrix flux potential, pressure head, water content, and total head. The horizontal variations were described by trigonometric functions in problems involving line sources and sinks and by Bessel functions in problems involving point sources and sinks. The regions below and above the sources and sinks were treated separately, subject, of course, to matching along the interface between the two regions. The vertical variations were described by exponential dampings and by surface and base reflections. For the flows to sinks, with each flow pattern there is associated an infinite variety of distributions of the matric flux potential, etc., corresponding to different suctions applied at the sinks. Some problems involving partial supply by sources and interception by sinks also were treated.

77:02G-027
A COMPARISON OF NUMERICAL SIMULATION MODELS FOR ONE-DIMENSIONAL INFILTRATION,
Haverkamp, R., Vauclin, M., Touma, J., Wierenga, P.J., and Vachaud, G.
Universite Scientifique et Medicale, Institut de Mecanique, Grenoble (France).
Soil Science Society of America Journal, Vol. 41, No. 2, p 285-294, March-April, 1977. 6 fig, 4 tab, 34 ref, 1 append.

Descriptors: *Model studies, *Mathematical models, *Infiltration, Numerical analysis, Soil water movement, Soils, Sands, Clays, Profiles, Moisture content, Hydraulic conductivity, Computer models, Equations, Soil science, Simulation analysis.

Six models, employing different ways of discretization of the nonlinear infiltration equation, were compared in terms of execution time, accuracy, and programming considerations. All models yielded excellent agreement with water content profiles measured at various times in a sand column. The two explicit models, the theta-based CSMP model and the h-based explicit model, used between 5 and 10 times more computer time than the implicit models. Results obtained with the two models which used the Kirchhoff integral transformation were no better than results obtained with the two h-based implicit models. The implicit schemes with implicit or explicit evaluation of the hydraulic conductivity and water capacity functions appear to have the widest range of applicability for predicting water movement in soil with both saturated and nonsaturated regions. Excellent agreement was obtained among water content distributions, infiltration rates, and cumulative infiltration volumes calculated with the implicit finite difference model and with Philip's quasi-analytical solution.

77:02G-028
INFILTRATION EQUATIONS FOR SIMPLE SOIL SYSTEMS,
Collis-George, N.
Sydney University, Department of Soil Science, (Australia).
Water Resources Research, Vol. 13, No. 2, p 395-403, April 1977. 3 fig, 1 tab, 24 ref.

Descriptors: *Infiltration, *Soil properties, *Model studies, *Soil water movement, *Infiltration rates, Mathematical models, Equations, Soils, Soil water, Hortons law, Dispersion.

Empirical equations and physically based equations used to describe vertical infiltration into simple soil systems were compared with experimental data. An empirical equation was proposed which satisfies the conditions that cumulative infiltration is proportional to the square root of time at short times and reaches a steady-state infiltration rate at long times. The equation, i = i sub o (square root of tanh T) + Kt, describes the observed behavior of simple soil systems at all times; where i is the cumulative infiltration at time t, K is the infiltration rate at steady-state, i sub o = S(square root of t sub c), and T = t/t sub c. The sorptivity, S, and a time parameter, t sub c, are soil properties determinable experimentally. The Green and Ampt equation and the Horton equation do not satisfy observed behavior at all times, the former failing at long times and the latter at short times. The equation of van der Want, the linearized Fokker-Planck equation of Philip, and the nonlinearized Fokker-Planck equation of Knight and Philip do not describe the observed behavior of simple soil systems over the whole time range as precisely as the proposed empirical equation. Since i sub o is not an independent part of the equations, its numerical value is defined by the independent parameters S and K; and for the materials examined, the numerical value is generally not the same as the experimental value. Procedures were outlined for treating experimental data, not necessarily complete for all times, to produce the three parameters, K, S, and t sub c for simple systems, and for description infiltration into cracking clays or in cases where ultrashort time effects occur.

77:02G-029
VERTICAL INFILTRATION IN DRY SOIL,
Brutsaert, W.
Cornell University, School of Civil and Environmental Engineering, Ithaca, New York.
Water Resources Research, Vol. 13, No. 2, p 363-368, April 1977. 26 ref.

Descriptors: *Infiltration, *Soils, *Vertical migration, *Infiltration rates, Dry beds, Sorption, Soil water movement, Capillary conductivity, Equations, Mathematical studies.

An approximate method was proposed to integrate the ordinary differential equations governing the terms in Philip's series formulation of the water content profile. The method is related to the weighing solution used earlier for the sorption problem, and it is intermediate between the quasi-steady state method and the sharp front method. In a comparison with an available exact solution, it was shown that the derived solution is usually accurate to within less 1%. The water content profile and the infiltration rate can be expressed concisely in terms of soil physical parameters by making use of suitable expressions for the soil water diffusivity and for the capillary conductivity. As an illustration, the infiltration rate was calculated for the Averjanov-Irmay capillary conductivity and for the author's three-parameter power function diffusivity. Inspection of two extreme cases in the calculation finally lead to a new infiltration equation in closed form which is valid for short and for large times of infiltration.

77:02G-030
FLOW CHARACTERISTICS DURING INFILTRATION INTO A HORIZONTAL SAND COLUMN,
Poulovassilis, A.
Agricultural Research Council, Unit of Soil Physics, Cambridge (England).
Water Resources Research, Vol. 13, No. 2, p 369-374, April 1977. 9 fig, 13 ref.

Descriptors: *Infiltration, *Diffusivity, *Soil water movement, Soil water, Flow, Laboratory tests, Darcys law, Hydraulic conductivity, Permeability, Groundwater, Groundwater movement, Hysteresis, Soil moisture, Reynolds number, Tensiometers, Porous media, Soils.

Experimental water content profiles established during infiltration into a horizontal sand column were compared with theoretical profiles calculated from the soilwater diffusivity, which was determined independently of the infiltration process. Discrepancies between the theoretical and experimental profiles were found. In particular, the experimental profiles for small times showed a retardation of the penetration which became more pronounced as the water content increased, and no unique relationship between the water content and the variable lambda=x/square root of t (x being the distance and t the time) was found. Thus, the experimental profiles gave incorrect and varying soil water diffusivities. The comparison of the actual flow rate q with the rate q' given by the product of the hydraulic conductivity and the observed potential gradient showed that q = alpha q', where alpha is between 0 and 1, alpha varying with the water content and the potential gradient. The effect of the "less than proportional" flow on the profile development was discussed. It was argued that the infiltration process at relatively late times was conditioned by the profile development during the very early stages. Previous experimental infiltration work was discussed, and it was argued that two mechanisms able to produce nonDarcian behavior may be responsible for the various reported infiltration patterns. Finally, the results of the present work were discussed in terms of a critical Reynolds number where the flow becomes nonDarcian.

77:02G-031
SCALING FIELD-MEASURED SOIL HYDRAULIC PROPERTIES USING A SIMILAR MEDIA CONCEPT,
Warrick, A.W., Mullen, G.J., and Nielsen, D.R.
Arizona University, Department of Soils, Water and Engineering, Tucson, Arizona.
Water Resources Research, Vol. 13, No. 2, p 355-362, April 1977. 2 fig, 1 tab,
12 ref.

Descriptors: *Hydraulic properties, *Soils, *Scaling, *Hydraulic conductivity, *Soil physical properties, Soil water movement, Unsaturated flow, Hydrology, Soil physics, Flow, On-site investigations.

Field data for soil water characteristic relationships and unsaturated hydraulic conductivity were scaled by using the concept of similar media in order to study water flow in spatially varying soils. Data observed by different investigators at three geographic areas were used. The soil water characteristic data consisted of 840, 900, and 512 observations, while data for the unsaturated hydraulic conductivity (available from only one of the three sources) consisted of 2,640 observations. In the process of scaling the data, a best fit for the scaled data was defined in terms of a sum of squares about an "average" curve, using one value for the scaling parameter for each sampling location. Comparisons made between curves fitting the data and curves fitting the scaled data showed that scaling reduces the sums of squares by amounts varying from 34 to over 90%. For similar media, the scaling parameter determined at a given sampling location for the soil water characteristic relationship (a sub r from h(S)) should be identical to the scaling parameter for the unsaturated hydraulic conductivity (a sub r from K(S)). Although the parameters were highly correlated (r = 0.91) for the only set of data available, a sub r from h(S) values were shown to be more effective in scaling the unsaturated hydraulic conductivity data than were a sub r from K(S) values in scaling soil water characteristic data.

77:02G-032
EFFECTS OF SPATIAL VARIABILITY OF SOIL HYDRAULIC PROPERTIES IN WATER BUDGET MODELING,
Peck, A.J., Luxmoore, R.J., and Stolzy, J.L.
Commonwealth Scientific and Industrial Research Organization, Division of Land Resources Management, Wembley (Australia).
Water Resources Research, Vol. 13, No. 2, p 348-354, April 1977. 4 fig, 4 tab,
22 ref.

Descriptors: *Soil properties, *Hydraulic properties, *Hydrologic budget, *Model studies, *Tennessee, Soil horizons, Hydraulic conductivity, Precipitation (atmospheric), Rain-runoff relationships, Soil water, Soil profiles, Darcys law, Retention, Infiltration, Evapotranspiration.

There is appreciable spatial variability of soil properties on the scale of a watershed of a field even in a single soil type. The spatial variation of soil water characteristics in an area was simulated from average properties and the assumption of scale heterogeneity. Simulated soil water characteristics and other data representing forest vegetation were used in a model to simulate water budgets over part of a watershed in eastern Tennessee for average April and July weather. Precipitation was assumed to be uniform over the area, and there was no runoff even from the least permeable soil during the months simulated. The spatial variability of soil water conditions had only a small effect on evapotranspiration. Water storage in the soil profile changed, so that the drainage flux beyond the root zone tended to become uniform throughout the area simulated. The characteristic microscopic length of the soil was assumed to be normally distributed in an area, and equations were developed for calculating average soil water characteristics from the retention curves and hydraulic conductivities of a number of soil samples. Components of the water budgets simulated with average soil water characteristics were in excellent agreement with the simulated behavior of the spatially variable soil unit as a whole. The result does not imply similar agreement for other distribution functions and soil-plant-weather combinations, but the methodology developed may be applied to investigate similar problems.

77:02G-033
HYSTERETIC STEADY STATE SOIL WATER PROFILES,
Poulovassilis, A., and El-Ghamry, W.M.

Agricultural Research Council, Unit of Soil Physics, Cambridge (England).
Water Resources Research, Vol. 13, No. 3, p 549-557, June 1977. 11 fig, 9 ref.

Descriptors: *Soil water, *Hysteresis, *Soil water movement, *Model studies, Soil moisture, Profiles, Theoretical analysis, Mathematical models, Laboratory tests, Analysis, Hydraulic conductivity, Unsaturated flow, Hydraulic models, Porous media, Capillary water, Fringe water, Pressure head, Moisture content, Data collections, Foreign research.

The shape of the hysteretic steady-state soil water profile was examined theoretically. It was shown that the hysteretic steady-state profile which results after wetting acquires usually minimum values of the soil water pressure head, of the hydraulic conductivity, and of the water content, values smaller than the asymptotic values approached at large heights. In contrast, the hysteretic steady-state profiles which result after drying do not show such minimum values. Experimental hysteretic steady-state profiles established in a vertical sand column confirmed the theoretical predictions and were in agreement with the predictions calculated numerically from the flow equation. It was concluded that the effects hysteresis on the soil water profile development may influence seriously the retention and movement of water in and out of the soil zone between the soil surface and the water table and, therefore, may modify the environment of plant root growth.

77:02G-034
SATELLITE MICROWAVE OBSERVATIONS OF SOIL MOISTURE VARIATIONS,
Schmugge, T.J., Meneely, J.M., Rango, A. and Neff, R.
National Aeronautics and Space Administration, Goddard Space Flight Center, Greenbelt, Maryland.
Water Resources Bulletin, Vol. 13, No. 2 p 265-281, April 1977. 11 fig, 1 tab, 7 ref.

Descriptors: *Remote sensing, *Soil moisture, *Central United States, Soils, Vegetation, Vegetation effects, Satellites (artificial), Aircraft, Microwaves, Rainfall, Antecedent precipitation, Precipitation (atmospheric), Soil water, Crops, Soil moisture meters, Measurement, Monitoring, Water resources, Agriculture.

Results from studies in the Illinois-Indiana and Texas-Oklahoma areas indicated that satellite microwave observations at the 1.55 cm wavelength are responsive to relative moisture variations in the near surface layer of the soil. Because significant vegetation cover absorbs the 1.55 cm microwave emission from the soil, the target area must be predominantly bare soil or low density vegetation cover for meaningful measurements to result. The 25 km resolution of the satellite sensor limits application of the microwave techniques to large areas such as watersheds or agricultural districts rather than individual fields. In general, at 1.55 cm, there is an inverse relationship between microwave brightness temperature and changes in soil moisture levels (as indicated by antecedent rainfall) in agricultural regions before planting of crops or during the early growing season when vegetation cover is sparse. Even early season observations should be of great value in deciding on the time and type of crop planting and for initial irrigation scheduling when the root zone is still in close proximity to the surface.

77:02G-035
NUMERICAL ANALYSIS OF TWO-DIMENSIONAL INFILTRATION AND REDISTRIBUTION,
Perrens, S.J., and Watson, K.K.
University of New England, School of Natural Resources, Armidale (Australia).
Water Resources Research, Vol. 13, No. 4, p 781-790, August 1977. 6 fig, 36 ref.

Descriptors: *Infiltration, *Soil water, *Soil moisture, *Model studies, Mathematical models, Soils, Soil types, Hysteresis, Hydraulic conductivity, Soil water movement, Pressure, Pressure head, Wetting, Soil physics, Soil science.

The two-dimensional flow equation for the movement of water in unsaturated porous materials was used to study an infiltration-redistribution sequence in which the surface flux is spatially nonuniform. A numerical analysis is based on a finite difference scheme involving the use of iterative alternating direction implicit techniques was found to describe the two-dimensional flow process satisfactorily. The program incorporates an interpolation-type hysteresis model which enables temporal as well as spatial variations of flux to be simulated. The flow regime was discussed with reference to two porous materials which have contrasting hydrologic characteristics. The two-dimensional profile distributions of water content and pressure head were represented at significant times by a series of perspective diagrams.

77:02G-036
NITRATE MOVEMENT IN CLAY SOILS AND METHODS OF POLLUTION CONTROL,
Swoboda, A.R.
Texas A & M University, Department of Soil and Crop Sciences, Texas Agricultural Experiment Station, College Station, Texas.
Proceedings of National Conference on Irrigation Return Flow Quality Management, Colorado State University, Fort Collins, Colorado, p 19-25, May 16-19, 1977. 2 fig, 5 tab, 6 ref.

Descriptors: Nitrates, Clays, Soils, Soil investigation, Pollution, Pollution control, Leaching, Lysimeters, Fertilizers, Runoff, Model studies, Nitrification, Crop response.

Movement of nitrates was measured in soils to determine quantitative amounts of losses. Leaching losses in lysimeters ranged from 0.04 to 6 percent depending on nitrogen source and climatic conditions. Nitrate concentrations in shallow wells within watersheds indicated that nitrates from applied fertilizer was leaching into the shallow groundwaters. Concentrations as high as 60 ppm NO3-N were found in some wells after the initial rains following fertilization. Runoff from the watershed contained very little nitrate and amounted to less than 4 percent of the fertilizer applied. A descriptive model of nitrate movement in clay soils is presented. Methods of reducing nitrate leaching in soils are discussed. Field studies indicated that inhibiting nitrification was an effective means of reducing nitrate movement from ammonium fertilizers. Slow release sulfur coated urea also reduced nitrate movement when applied in the fall or winter. Delaying fertilization until planting was also an effective means of reducing nitrate losses without reducing yields.

77:02G-037
EFFECT OF THREE IRRIGATION SYSTEMS ON DISTRIBUTION OF FERTILIZER NITRATE NITROGEN IN SOIL,
Onken, A.B., Wendt, C.W., Wilke, O.C., Hargrove, R.S., and Bausch, W.
The Texas A & M University System, Texas Agricultural Experiment Station, Lubbock, Texas.
Proceedings of National Conference on Irrigation Return Flow Quality Management, Colorado State University, Fort Collins, Colorado, p 27-32, May 16-19, 1977. 9 tab, 2 ref.

Descriptors: Irrigation, Irrigation systems, Fertilizers, Nitrates, Soils, Fertilization, Corn, Sprinkler irrigation, Furrow irrigation, Subsurface irrigation.

Sweet corn was grown two years on a Miles loamy fine sand fertilized with band applied 15N enriched sodium nitrate. Two plots, 6 x 6 m, were established under each of the three irrigation systems-sprinkler, furrow and subirrigation. A starter band of fertilizer was applied 7.6 x 7.6 cm from the seed with the rest sidedressed 25 cm either side of the center of the seedbed. Total nitrogen applied was 124 kg/ha in 1973 and 105 kg/ha in 1974. In 1974, each of the six plots that were established in 1973 were divided in half, one half receiving 15N enriched fertilizer as sodium nitrate, and the other half receiving the same amount of unenriched sodium nitrate. Soil samples were taken periodically from furrow to furrow in lateral distance increments of 25 cm and through the starter fertilizer band to a depth of 5.2 m in 30 cm increments. Plant samples were obtained at the end of each growing season. Soil and plant samples were analyzed using standard procedures. Fertilizer nitrogen moved differently under the three irrigation systems. When sprinkler-irrigated, fertilizer bands tended to maintain their integrity during downward movement. Under furrow irrigation, fertilizer bands tended to merge in the center of the bed and move downward. Under subirrigation, fertilizer tended to move down under the furrows. At the end of two crop years, greatest depth movement of fertilizer nitrogen was under sprinkler irrigation and least under subirrigation.

77:02G-038
VARIABILITY OF NITRATE LEACHING WITHIN DEFINED MANAGEMENT UNITS,
Lund, L.J., and Pratt, P.F.
California University, Riverside, California.
Proceedings of National Conference on Irrigation Return Flow Quality Management,
Colorado State University, Fort Collins, Colorado, p 45-53, May 16-19, 1977.
6 fig, 6 tab, 20 ref, 7 equ.

Descriptors: Soils, Soil investigations, Fertilizers, Fertilization, Return flow, Nitrates, Leaching, Sampling, California.

In attemping to relate nitrate concentrations below root zones to root zone soil characteristics, the experimental approach has consisted of a comparison of a number of sites within a defined management unit or field. The basic assumption in this approach has been that the management of the field is uniform and variations in nitrate leaching result from variations in soil characteristics. However, results reported herein show that even within a field of limited size, other sources and sinks can be significantly different at various sampling locations. The variation in these factors for a number of fields in the Santa Maria Valley, California is discussed.

77:02G-039
FIELD MEASURED FLUX OF VOLATILE DENITRIFICATION PRODUCTS AS INFLUENCED BY SOIL WATER CONTENT AND ORGANIC CARBON SOURCE,
Rolston, D.E., Goldhamer, D.A., Hoffman, D.L., and Toy, D.W.
California University, Department of Land, Air, and Water Resources, Soils and Plant Nutrition Section, Davis, California.
Proceedings of National Conference on Irrigation Return Flow Quality Management,
Colorado State University, Fort Collins, Colorado, p 55-61, May 16-19, 1977.
5 fig, 1 tab, 10 ref, 2 equ.

Descriptors: Irrigation, Soils, Soil investigations, Soil moisture, Return flow.

The amount of NO3 in irrigation return flow waters is dependent upon each of the components of the N cycle in soils. One of those components for which absolute amounts and rates are not well known is denitrification. Volatile denitrification products, primarily N2O and N2, are evolved whenever anoxic sites develop within the soil and when sufficient carbon is available. Absolute amounts and rates of denitrification from a Yolo loam field profile at Davis, California, were studied in relation to the influence of soil-water content and organic carbon source. Field plots were intensely instrumented with soil atmosphere samplers, soil solution samplers, and tensiometers. Soil-water pressure heads (h) in the upper 15 cm of soil were maintained constant at -15 and -70 cm of water. Three levels of soil carbon were evaluated from plots cropped with ryegrass, uncropped plots, and plots to which manure was mixed in the top 10 cm of soil. Fertilizer was applied at the rate of 300 kg N ha-1 as KNO3 enriched with 20 and 40 percent 15N for the h = -15 and h = -70 cm treatments, respectively. The flux of volatile gases at the soil surface was measured from the accumulation of N2O and 15N2 beneath an airtight cover placed over the soil surface for 1 or 2 hours per day. Denitrification occurred in order of decreasing magnitude in manure (h = -15 cm), manure (h = -70 cm), uncropped (h = -15 cm), and uncropped (h = -70 cm) plots. Approximately 70 percent of the fertilizer nitrogen was denitrified for the manure (h = -15 cm) treatment. Approximately 1 percent of the added fertilizer was denitrified in the uncropped (h = -70 cm) treatment.

77:02G-040
SOIL NITRATE CONCENTRATIONS IN CORN PLOTS TREATED WITH ISOTOPICALLY LABELED NITROGEN FERTILIZER,
Broadbent, F.E., and Carlton, A.B.
California University, Department of Land, Air and Water Resources, Soils and Plant Nutrition Section, Davis, California.
Proceedings of National Conference on Irrigation Return Flow Quality Management,
Colorado State University, Fort Collins, Colorado, p 63-69, May 16-19, 1977.
8 fig, 4 tab, 6 ref.

Descriptors: Nitrates, Nitrogen, Soils, Fertilizers, Sampling, Soil physical properties.

Soil solution composition has been monitored for 3 years at depths ranging from 30 to 300 cm at an experimental site on Yolo fine sandy loam where 15N-depleted ammonium sulfate has been applied at 0, 90, 180, and 360 kg N per year. Samples have been taken at approximately 2-week intervals during the growing season and less frequently during the winter and early spring. In unfertilized plots receiving 60 cm/yr irrigation water NO3-N concentrations fluctuated widely near the surface, ranging from 3-4 up to about 35 ppm over a 2-1/2 year period. At lower depths fluctuations were not as great, but at 300 cm NO3-N consistently remained above 10 ppm. At 90 and 180 kg-fertilizer N, the latter level being sufficient to produce the maximum grain yield, very little NO3-N derived from fertilizer was found below 120 cm. However, at the 360 kg level, fertilizer-derived nitrate was found to constitute a significant fraction of the total at all depths down to 300 cm.

77:02G-041
THEORETICAL AND EXPERIMENTAL OBSERVATIONS OF WATER AND NITRATE MOVEMENT BELOW A CROP ROOT ZONE,
Biggar, J.W., Tanji, K.K., Simmons, C.S., Gupta, S.K., and MacIntyre, J.L.
California University, Department of Land, Air and Water Resources, Davis, California.
Proceedings of National Conference on Irrigation Return Flow Quality Management, Colorado State University, Fort Collins, Colorado, p 71-77, May 16-19, 1977.
9 fig, 1 tab, 4 ref, 3 equ.

Descriptors: Soils, Soil investigations, Soil water movement, Soil water, Crop production, Leaching, Nitrogen, Irrigation.

A report of the progress of an experiment which attempts to deal with the spatial variability of a field soil is presented. The experimental objective is to measure the flux of water and nitrate leaching below the root zone of a crop by examining the behavior of nitrogen applied to a corn crop grown under irrigation.

77:02G-042
MINIMIZING SALT IN RETURN FLOW BY IMPROVING IRRIGATION EFFICIENCY,
van Schilfgaarde, J.
United States Department of Agriculture, Agricultural Research Service, United States Salinity Laboratory, Riverside, California.
Proceedings of National Conference on Irrigation Return Flow Quality Management, Colorado State University, Fort Collins, Colorado, p 81-98, May 16-19, 1977.
19 fig, 4 tab, 24 ref.

Descriptors: Salinity, Saline water, Irrigation efficiency, Agriculture, Colorado river, Leaching, Arizona.

Return flow from irrigated agriculture has been identified as the major source of salinity in the Colorado River that may be controlled. Thus, if the trend of increasing salinity is to be reversed, it appears that irrigated agriculture must bear a large portion of the burden. Research at the United States Salinity Laboratory indicates irrigated agriculture can reduce its contribution by efficient irrigation that provides water of low salinity in the upper portion of the crop root zone while the salinity of the water in the lower portion can be permitted to concentrate considerably more than had previously been suspected without decreased yields. If these results hold true under field conditions, the leaching requirement of most crops grown with Colorado River water could be reduced below 10%. Lower leaching requirements, if achieved, would also reduce salt discharge to the river due to precipitation of lime and gypsum in the soil and because of decreased salt pickup from saline underground sources. To evaluate the minimum leaching concept for alleviating the salinity problem of a major river basin, two field studies have been initiated in the Wellton-Mohawk Irrigation and Drainage District of southwestern Arizona. The first field experiment was installed in December 1973 in citrus on coarse-textured, mesa soil, and the second was started in September 1974 in alfalfa on fine-textured, valley soil. The paper will describe the experimental design of both experiments and initial data on crop water use, soil salinity profiles, and leaching fractions achieved will be presented.

77:02G-043
AREAL PREDICTIONS OF SOIL WATER FLUX IN THE UNSATURATED ZONE,
Warrick, A.W.
Arizona University, College of Agriculture, Department of Soils, Water and Engineering, Tuscon, Arizona.
Proceedings of National Conference on Irrigation Return Flow Quality Management, Colorado State University, Fort Collins, Colorado, p 225-231, May 16-19, 1977.
8 fig, 14 ref.

Descriptors: Soil water, Soil water movement, Soils, Soil investigations, Irrigation, Salinity, Hydraulic conductivity.

Irrigation, salinity and potential ground or surface water pollutants are intimately related to water and solute movement in the soil profile. Ideally, soil water fluxes and water composition are managed in order to provide a desirable plant growing environment and/or acceptable quantities and qualities of drainage water. The problem of predicting or averaging such fluxes is very difficult due to the intrinsic variability of the soil's physical and chemical properties. In this study, predictions of soil water flux are made accounting for the spatial variability of the soil water parameters. Calculations are made using field-measured distributions of conductivity and soil water tension -- water content relationships for Panoche loam and Pima clay loam soils. In the second set of calculations, flux distributions are found using the more cumbersome, finite difference solution to the nonlinear moisture flow equation. This allows inclusion of more realistic boundary conditions as well as plant water uptake. The results are a step towards finding the most effective way of determining and expressing water flux as a function of time. Also, addressed are reliability of areal predictions and measurements.

77:02G-044
HYDRO-SALINITY MODELS: SENSITIVITY TO INPUT VARIABLES,
Oster, J.D., and Wood, J.D.
United States Department of Agriculture, Agricultural Research Service, United States Salinity Laboratory, Riverside, California.
Proceedings of National Conference on Irrigation Return Flow Quality Management, Colorado State University, Fort Collins, Colorado, p 253-259, May 16-19, 1977.
7 fig, 2 tab, 6 ref, 9 equ.

Descriptors: Model studies, Simulation analysis, Water quality, Return flow, Salinity, Irrigation efficiency.

Return flows estimated from salinity, or a water budget analysis, exhibit opposite sensitivities to increasing field irrigation efficiencies. However, the sensitivities of both methods to assess return flows may be complementary if both are used to obtain an optimized estimate of return flows. The degree of data uncertainty would undoubtedly be greater in areas with multiple return flow paths, greater sources of underflows and rainfall, and shorter growing seasons.

77:02G-045
AGRICULTURAL DRAINAGE PROBLEMS OF THE SAN JOAQUIN VALLEY,
Price, E.P.
United States Bureau of Reclamation, Sacramento, California.
Proceedings of National Conference on Irrigation Return Flow Quality Management, Colorado State University, Fort Collins, Colorado, p 283-287, May 16-19, 1977.
2 fig, 1 tab.

Descriptors: Agriculture, California, Drainage districts, Drainage practices, Drainage.

A brief description of the physical setting of the San Joaquin Valley and the drainage problems anticipated are presented. Estimates are preliminary and subject to revision as studies continue.

77:02G-046
PORTLAND CEMENT AS A SOIL AMENDMENT FOR CORN AND SOYBEANS,
Stivers, R.K., Swartzendruber, D., and Nyquist, W.E.,
Purdue University, Department of Agronomy, West Lafayette, Indiana 47907.

Agronomy Journal, Vol. 69, No. 6, p 961-964, November-December, 1977. 3 tab, 7 ref.

Descriptors: Corn, Soybeans, Soil amendment, Soil water, Hydraulic conductivity, Infiltration, Soil properties, Soil physical properties, Soil treatment, Soil water movement, Cements.

In the corn belt there are many areas of imperfectly drained soils, often adjacent to well-drained soils in the same fields. Tile drainage of these imperfectly drained soils helps remove excess water within the profile. Slow movement of water into and through the Ap horizon of these soils is thought to contribute to reduced crop yields in wet years. Since application of Portland cement (the binding material in concrete) to soil in a laboratory experiment increased water-stable soil aggregate size as well as hydraulic conductivity of a soil, it was assumed that cement would act similarly in the field and increase crop yields, particularly under wet conditions.

77:02G-047

COMPARISON OF METHODS OF CALIBRATION OF A NEUTRON PROBE BY GRAVIMETRY OR NEUTRON-CAPTURE MODEL,

Vachaud, G., Royer, J.M., and Cooper, J.D.
Grenoble-1 University, Inst. de Mecanique, (France).
Journal of Hydrology, Vol. 34, No. 3/4, p 343-356, August 1977. 3 fig, 1 tab, 21 ref.

Descriptors: *Soil moisture meters, *Soil water, *Calibrations, *Analytical techniques, *Nuclear moisture meters, Instrumentation, Chemical properties, Nuclear meters, Gravimetry, Soil analysis, Mathematical studies, Soil properties, Soil moisture, Gravimetric analysis, Soil tests, Moisture content, Methodology.

Presented was a systematic analysis of 2 methods used for determining calibration curves of neutron probes. The uncertainties resulting from the use of the gravimetric method, with a linear correlation between count rates and water content of soil samples, were considered first. Particular care was given to the determination of errors in the values of water content and count rates and to the difficulties arising from the choice of the correlation technique. The neutron-calibration curve of the soil also was obtained with a technique based on the determination of neutron thermal absorption and diffusion constants. The importance of errors associated with the method was also analyzed. Different field examples then were presented. It appears that the neutron-capture technique should be particularly well suited for determining the calibration curve of clay soils or heterogeneous materials for which the gravimetric calibration technique cannot be applied with confidence. On the other hand, it also was shown that for a soil with a very well-defined gravimetric calibration curve, the neutron-capture technique gives results still at least as good as with the former method.

77:02G-048

THE UNSTEADY GROUNDWATER MOUND BELOW AN IRRIGATION DITCH OR LEAKY CANAL,

Young, E.G.
Agricultural Research Council, Unit of Soil Physics, Cambridge (England).
Journal of Hydrology, Vol. 34, No. 3/4, p 307-314, August 1977. 3 fig, 6 ref.

Descriptors: *Soil water, *Seepage, *Canals, *Model studies, Laboratory tests, Mathematical models, Irrigation, Groundwater, Soil water movement, Groundwater movement, Water table, Equations, Irrigation ditches, Irrigation canals, Infiltration.

The groundwater mound which develops below an irrigation ditch or leaky canal was investigated experimentally using a hydraulic sand-tank model and a Hele-Shaw analogue. The results showed that the mound built up in height at a rate proportional to the cube root of time and moved laterally at a rate proportional to the cube root of the time squared, as predicted from a solution of the Boussinesq equation, obtained numerically after using Barenblatt's transformation.

77:02G-049
MODELING SOIL WATER MOVEMENT FOR TRICKLE IRRIGATION-PHASE II,
Warrick, A.W., and Lomen, D.O.
Arizona University, Department of Soils, Water and Engineering, Tucson, Arizona.
Available from the National Technical Information Service, Springfield, Virginia 22161 as PB-272, 625, Price codes: A03 in paper copy, A01 in microfiche. Completion Report, August 1977. 27 p, 13 fig, 4 tab, 34 ref.

Descriptors: *Unsaturated flow, *Soil water movement, *Model studies, Irrigation, Evaporation, Moisture content, Evapotranspiration, Fruit crops, Orchards.

This study is a continuation of the previous project whose goal was to develop techniques for the solution of the moisture flow equation for conditions of trickle and high-frequency irrigation. Several solutions have been found for the linearized forms of the moisture equation including flow from a line source above a shallow water table, flow from lines and points with evaporation at the surface and one and two-dimensional flows with plant water uptake. Comparisons of the analytical solutions for the linearizing assumptions were made with finite difference results of the nonlinear moisture equation. Results are somewhat encouraging. Conditions favoring the analytical over the numerical solutions are short irrigation cycles, uncertain input data, complex geometries, and expensive computer time. In addition to the mathematical modeling, field measurements were made regarding the microclimate surrounding lemon trees in a trickle-irrigated orchard. Results in June showed evapotranspiration to be on the order of 0.2 - 0.4 of the open pan evaporation and about three times as large if just the canopy area was considered.

77:02G-050
RAINFALL INFILTRATION INTO BARE SOILS,
Morin, J., and Benyamini, Y.
Ministry of Agriculture, Soil Conservation and Drainage Division, Tel-Aviv (Israel).
Water Resources Research, Vol. 13, No. 5, p 813-817, October 1977. 5 fig, 3 tab, 6 ref, 1 append.

Descriptors: *Infiltration, *Model studies, *On-site investigations, Mathematical models, Soils, Soil properties, Precipitation (atmospheric), Rainfall, Rainfall intensity, Mulching, Impact (rainfall), Infiltration rates, Agriculture.

Raindrop impact destroys the surface aggregates of soils and gradually forms a continuous crust. Infiltration rates of bare soils are determined by the mentioned process. A theoretical model presented previously was tested under field conditions with a sandy loam soil. The effect of the crust's structure was tested under three rainfall intensities and in wetting and drying cycles. The results of the tests confirmed the theoretical model. The study demonstrated quantitatively that the major factor determining the reduction of infiltration rates is crust formation and not moisture regime.

77:02G-051
SOIL THERMAL DIFFUSIVITY DETERMINATION FROM OVERSPECIFICATION OF BOUNDARY DATA,
Singh, S.R., and Sinha, B.K.
Punjab Agricultural University, Department of Agricultural Engineering, Ludhiana-141004, India.
Soil Science Society of America Journal, Vol. 41, No. 5, p 831-834, September-October, 1977. 1 fig, 1 tab, 18 ref.

Descriptors: Heat, Diffusivity, Soils, Soil investigations, Soil temperatures, Soil profiles, Mathematical studies.

The heat conduction equation has been solved for evaluating thermal diffusivity of soils by overspecifying the usual boundary conditions in terms of the thermal gradient at the boundary surface. Solutions have been obtained for difference Dirichlet-type boundary conditions describing the boundary temperature. These were (a) linearly rising/falling, (b) exponentially rising, (c) exponentially falling, and (d) sinusoidal. The thermal gradient in the soil profile was evaluated using a cubic spline. Field data were analyzed firstly by representing the surface temperature as linearly rising and secondly as sinusoidal. More consistent results were obtained with the help of the first approximation which represented the boundary data closely. This shows that a close approximation of boundary condition by an appropriate function is essential to get reliable values of the thermal diffusivity.

77:02G-052
ON THE USE OF THE LANGMUIR EQUATION IN THE INTERPRETATION OF "ADSORPTION" PHENOMENA,
Veith, J.A., and Sposito, G.
Institute for Anorganische Chemie der Freien University, Berlin, 1 Berlin 33, Fabeckstrasse 34/36, West Germany.
Soil Science Society of America Journal, Vol. 41, No. 4, p 697-702, July-August, 1977. 5 fig, 29 ref, 12 equ.

Descriptors: Model studies, Simulation analysis, Anions, Soils, Soil investigations, Phosphorus, Adsorption.

A theoretical discussion in terms of molecular theory and the results of model experiments are employed to demonstrate that the conventional analysis of "anion fixation" data, through linear least squares regression of the points in a Langmuir plot, usually will not be sensitive enough to show the failure of the Langmuir equation reaction. The theoretical discussion points out that although the Langmuir equation is not restricted to two-dimensional phenomena (in other words, adsorption), it cannot apply if the reacting anions must be present at some threshold concentration before fixation occurs. An analysis of model experiments on the reactions of OH(-) with Al(-) or Fe-resin and of Cl(-) with Ag-resin shows that secondary precipitation phenomena always result in a statistically significant, linear correlation of the variables in a Langmuir plot if the concentration of the reacting anions is much larger than the threshold value needed to initiate precipitation of the secondary solid phase. This condition generally can be expected to be met when anions such as O-phosphate react with soils or soil constituents.

77:02G-053
SOIL ACIDITY FROM LONG-TERM USE OF NITROGEN FERTILIZER AND ITS RELATIONSHIP TO RECOVERY OF THE NITROGEN,
Jolley, V.D., and Pierre, W.H.
Agricultural Home Economics Experiment Station, Ames, Iowa.
Soil Science Society of America Journal, Vol. 41, No. 2, p 368-373, March-April, 1977. 2 fig, 6 tab, 11 ref.

Descriptors: Nitrogen, Nutrients, Fertilizers, Fertilization, Corn, Crop response, Nitrification, Crop production, Denitrification, Soils.

Two N-rate experiments in which corn had been grown continuously for 15 and 17 years were used: (1) to study quantitatively the amounts of acidity that had been developed at different levels of N fertilization and (2) to determine to what extent the acidity produced can be explained and predicted from the amounts of N recovered in the crops and in the soil as NO3-N and organic N. The measured acidity was compared with the acidity calculated from N recovery, and both were expressed as percentages of the theoretical (potential) acidity developed from nitrification.

77:02G-054
TRACING VERTICAL TRANSLOCATION OF SOIL MOISTURE,
Ligon, J.T., Wilson, T.V., Allen, J.P., and Singh, U.P.
Clemson University, Department of Agricultural Engineering, South Carolina.
Journal of the Hydraulics Division, American Society of Civil Engineers, Vol. 103, No. HY10, Proceedings Paper 13290, p 1147-1158, October 1977. 8 fig, 8 ref, 1 append.

Descriptors: *Soil water movement, *Tritium, *South Carolina, Sampling, Iodine, Iodine radioisotopes, Tracers, Radioisotopes, Diffusion, Soil water, Groundwater, Seepage, Soil moisture, Soils, Clays, Unsaturated flow, Dispersion, Drainage.

Tracer experiments using tritium tagged water were initiated during December 1972-January 1973 to determine the rate of downward displacement of water in unsaturated Piedmont profile. Tritium location was monitored by daily soil sampling immediately after injection of activity and at frequencies decreasing to once every 6 months after 1 year. At the end of 23 months, the maximum level of activity was 24.8 ft (7.56 m). The observed rate of movement will bring the maximum tritium activity to the water table level of 65 ft (20 m) in about 6 years. Under conditions at the research site, lateral displacement of the materials was negligible. Some detention of activity in the high-clay B-horizon of the soil was observed.

77:02G-055
IRRIGATION SCHEDULING WITH NEUTRON PROBE,
Gear, R.D., Dransfield, A.S., and Campbell, M.D
United States Department of the Interior, Bureau of Reclamation, Lower Colorado Region, Boulder City, Nevada.
Journal of the Irrigation and Drainage Division, American Society of Civil Engineers, Vol. 103, No. IR 3, p 291-298, September 1977. 3 fig, 3 ref.

Descriptors: Irrigation, Irrigation practices, Soil water, Soil moisture, Soil water movement, Soil properties.

A simple accurate technique has been worked out to schedule irrigations, using a graphic display of neutron probe measurements. The neutron probe design has been changed to combine the scaler with the shield and provide a useful tool from what has traditionally been used almost exclusively for research. The technique used for scheduling irrigation requires only the identification of the refill point for each field and the neutron measured water content with time.

77:02G-056
A QUICK METHOD FOR ESTIMATING SOIL WATER DIFFUSIVITY FUNCTIONS,
Miller, R.D., and Bresler, E.
Cornell University, Agricultural Experiment Station, Department of Agronomy, Ithaca, New York.
Soil Science Society of America Journal, Vol. 41, No. 5, p 1020-1022, September-October, 1977. 1 fig, 4 ref.

Descriptors: *Diffusivity, *Soil water movement, *Infiltration, Model studies, Mathematical models, Equations, Regression analysis, Analytical techniques, Soils, Soil properties, Soil water, Physical properties, Laboratory tests, Soil science, Wetting fronts, Horizontal infiltration.

Published data for horizontal infiltration into air dry nonsodic stable soil imply excellent correlation between soil water diffusivity functions and the rate of advance of the visual wetting front in one dimensional horizontal infiltration experiments. When suitably transformed, data for each of eight soils, ranging from a clay loam to a sieved sand fraction, were represented remarkably well by a single regression equation involving dimensionless variables. This suggests that the same coefficients should apply to similar data for almost any soil. It was shown that the data also can be expressed for a somewhat simpler regression equation, involving only the simplest of experimentally measured quantities so that the diffusivity function can be quickly estimated for any soil.

77:02G-057
QUANTITATIVE RELATIONSHIPS AMONG NUTRIENTS LEACHED FROM SOILS,
Terman, G.L.
Tennessee Valley Authority, National Fertilizer Development Center, Soils and Fertilizer Research Branch, Muscle Shoals, Alabama 35660.
Soil Science Society of America Journal, Vol. 41, No. 5, p 935-940, September-October, 1977. 1 fig, 5 tab, 21 ref.

Descriptors: Nutrients, Fertilizers, Leaching, Soils, Soil investigations, Anions, Cations, Lysimeters.

This study was undertaken in an attempt to quantify relationships among anions (An) and cations (Cat) leached from soils. Several sets of published data on leaching of ions from acid and nonacid soils were evaluated by linear regression calculations based on the chemical equivalency of summation of Cat and summation of An leached. Calcium, Mg, K, and Na comprised most of summation of Cat, and NO3, SO4, and Cl, most of summation of An. Bicarbonate is also leached from nonacid soils; H is assumed to account for most of the excess of summation of An over summation of Cat in leachates from acid soils. Amounts of ions leached were much more closely correlated with leachate volumes among soils and time periods than with leachate volumes from various treatments for a given time period.

77:02G-058
WATER INFILTRATION AND RUNOFF UNDER RAIN APPLICATIONS,
Hachum, A.Y., and Alfaro, J.F.
Utah State University, Department of Agriculture and Irrigation Engineering,
Logan, Utah.
Soil Science Society of America Journal, Vol. 41, No. 5, p 960-966, September-
October, 1977. 9 fig, 4 tab, 13 ref.

Descriptors: *Infiltration, *Runoff, *Model studies, *Laboratory tests, Simulated rainfall, Mathematical models, Ponding, Pressure head, Wetting, Irrigation, Sprinkler irrigation, Rainfall, Soils, Soil water, Saturation, Soil science.

Experiments to verify the validity and to evaluate the performance of rain infiltration models based on extending the Green and Ampt approach are lacking in the literature. There are severe gaps between theory, validity, and practicality of these models. In this study, a physically based model for describing infiltration into a homogeneous deep stable soil profile with uniform initial water content distribution was presented. The derivation of the model was based on the concept of mapping the actual wetted soil zone into an equivalent rectangular saturated zone with constant effective hydraulic conductivity and capillary pressure head at the abrupt wetting front. The model took into account the initial water mobility in the soil profile and predicted the system response under any rainfall pattern. The proposed model was further simplified, for practical purposes, by grouping 3 basic input parameters into a single parameter, the Surface Saturation Index. The validity of the model was tested and was supported strongly by the results of laboratory experiments conducted on samples of 3 soils, 2 silt loams and a silty clay loam, under 5 different (variable and constant) water application rate patterns. It was found that the amount of runoff from a nearly symmetrical convex variable rainfall pattern was very close to that which resulted from its equivalent average constant application rate pattern, regardless of the significant differences between the times at which runoff begins and the characteristics of infiltration rates thereafter.

77:02G-059
MICRONUTRIENT CONCENTRATIONS IN SOIL SOLUTION AFTER AMMONIUM PHOSPHATE APPLICATIONS,
Mortvedt, J.J., and Osborn, G.
Tennessee Valley Authority, Soils and Fertilizer Research Branch, Division of Agricultural Development, Muscle Shoals, Alabama 35660.
Soil Science Society of America Journal, Vol. 41, No. 5, p 1004-1009, September-
October, 1977. 7 tab, 19 ref.

Descriptors: Ammonium, Fertilizers, Fertilization, Phosphates, Soils, Soil investigations, Phosphorus.

Two fluid ammonium polyphosphates and an equimolar mixture on mono- and diammonium phosphate, each with a solution pH of about 6.2, were well mixed with 1 kilogram lots of several soils to supply 2,000 parts per million of P, which approximates the P concentration in soil near a fertilizer band at a P rate of 50 kilograms per hectare. Each soil was then moistened to 0.2 or 0.3 atm and stored in plastic bags. After periods up to 28 days, soil samples were placed in a lucite cell and a portion of the soil solution was expressed by N2 gas. These solutions were analyzed for Cu, Fe, Mn, Zn, organic C, and total and orthophosphate P.

77:02G-060
TEST OF A SOIL WATER MODEL UNDER FIELD CONDITIONS,
Beese, F., Van der Ploeg, R.R., and Richter, W.
Goettingen University, Institute Soil Science and Forest Nutrition, (West Germany).
Soil Science Society of America Journal, Vol. 41, No. 5, p 979-984, September-
October, 1977. 4 fig, 2 tab, 27 ref.

Descriptors: *Soil water, *Unsaturated flow, *Evaporation, *Mathematical models, On-site investigations, Model studies, Lysimeters, Moisture content, Soil water movement, Soils, Soil properties, Precipitation (atmospheric), Rainfall, Drainage, Subsurface drainage, Agriculture.

A 218-day experiment on a fallow loess soil was carried out to study infiltration and redistribution under natural field conditions. On an experimental plot of 6 by 6 m, tensiometers were installed at 11 depths, 10, 20, 40, 60, 80, 100, 120, 140, 160, 180, and 200 cm. The tensiometers were read at short irregular intervals. The precipitation was measured daily. The hydraulic functions of the layered, horizontal soil and a relation between potential evaporation, actual evaporation, and the soil suction at 5-cm depth had been established previously. With use of these soil and atmospheric data, the unsaturated soil moisture flow equation was solved numerically. The purpose of the numerical analysis was to determine if the unsaturated soil moisture flow equation does describe observed soil moisture behavior for such a long period. It was found that the calculated soil suction values for all depths deviated less than 15% from the measured ones. It was concluded that the unsaturated moisture flow equation can be a useful means to supplement field measurements on infiltration, redistribution, evaporation, and internal drainage.

77:02G-061
FLOW FROM A LINE SOURCE ABOVE A SHALLOW WATER TABLE,
Warrick, A.W., and Lomen, D.O.
Arizona University, Department of Soils, Water and Engineering, Tucson, Arizona 85721.
Soil Science Society of America Journal, Vol. 41, No. 5, p 849-852, September-October, 1977. 3 fig, 1 tab, 8 ref.

Descriptors: Irrigation, Irrigation practices, Irrigation systems, Subsurface irrigation, Hydraulic conductivity, Soil water, Soil water movement, Porous media.

An analytical solution is developed for a buried line source with an underlying constant potential surface. The geometry is appropriate to describe flow from a trickle or subsurface irrigation system of porous pipe or emitters spaced closely in a line above a shallow water table or in a lysimeter. Assumptions include steady-state conditions and a hydraulic conductivity exponentially related to the pressure head. The soil water pressure head distribution is calculated for two geometries one for which the water table dominates over the line source throughout the flow medium, and a second for which most of the flow region is as if the source were above an infinitely deep lower boundary.

77:02G-062
TRACING THE TRANSFORMATIONS OF UREA FERTILIZER DURING LEACHING,
Wagenet, R.J., Biggar, J.W., and Nielsen, D.R.
Utah State University, Department of Soil Science and Biometeorology, Logan, Utah 84322.
Soil Science Society of America Journal, Vol. 41, No. 5, p 896-902, September-October, 1977. 8 fig, 5 tab, 22 ref.

Descriptors: Urea, Fertilizers, Fertilization, Nutrients, Leaching, Soils, Soil investigations, Mathematical studies, Kinetics, Model studies, Nitrification, Denitrification.

The transport and transformation of urea, NH(4+), and NO(3-) in soil were mathematically described as functions of depth and time, subject to either steady feed or pulse application of N, using relationships derived by assuming diffusion and mass transfer as transport processes and first-order kinetics as a transformational mechanism. The mathematical model was used to study the enzymatic hydrolysis of urea, nitrification, and denitrification in laboratory soil columns. Urea hydrolysis was found to be independent of initial urea concentration and the O2 concentration of the soil atmosphere. The rate of nitrification under transient N conditions was found to be one order of magnitude greater than the rate of denitrification when there was 20% O2 in the soil atmosphere. Populations of nitrifiers were found to increase in response to successive applications of N.

77:02G-063
NITRATE DISSIMILATION AND POPULATION DYNAMICS OF DENITRIFYING BACTERIA DURING SHORT TERM CONTINUOUS FLOW,
Volz, M.G., and Starr, J.L.
Department of Ecology and Climatology, and of Soil and Water, the Connecticut Agricultural Experiment Station, New Haven, Connecticut.
Soil Science Society of America Journal, Vol. 41, No. 5, p 891-896, September-October, 1977. 4 fig, 2 tab, 20 ref.

Descriptors: Nitrates, Denitrification, Soils, Soil investigations, Nitrogen.

A solution containing 100 micrograms ml(-1) of NO3(-) - N, 200 micrograms ml(-1) of glucose-C, and 0.01N CaSO4 was supplied continuously to soil in acrylic plastic columns (6 cm inside diam. x 10 cm length) for up to 96 hours while N2 gas was passed through the system. Concentrations of NO3(-) - N in the effluent decreased to 20 micrograms ml(-1) after 60 hours. Simultaneously, NO2(-) - N concentrations increased from traces to 65 micrograms ml(-1) and more than 70% of applied C had been utilized after 60 hours. These results indicate that most C oxidation was coupled with NO3(-) reduction although nearly all applied NO3(-) was ultimately denitrified after 96 hours.

77:02G-064

HYDROLYSIS AND DECOMPOSITION OF CALCIUM MONTMORILLONITE,

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Soil Science Society of America Journal, Vol. 41, No. 5, p 887-891, September-October, 1977. 3 fig, 2 tab, 12 ref.

Descriptors: Calcium, Montmorillonite, Clays, Leaching, Cation exchange.

The extent to which exchangeable calcium hydrolysis occurs during the preparation of homoionic calcium montmorillonite clay and the rate of the reaction in distilled water at various suspension concentrations and levels of CO2 was determined at 25 degrees C. The rate and extent of hydrolysis was found to be comparable to that reported for sodium montmorillonite and increased with CO2 concentration. CEC was appreciably reduced during washing of residual salts while preparing calcium montmorillonite. The mechanism of hydrolysis is discussed.

77:02G-065

DRAINAGE FLUX IN PERMEABLE SOIL UNDERLAIN BY A COARSE-TEXTURED LAYER,

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Soil Science Society of America Journal, Vol. 41, No. 4, p 671-676, July-August, 1977. 9 fig, 13 ref.

Descriptors: *Hysteresis, *Lysimeters, *Model studies, Tensiometers, Drainage, Hydraulics, Soil science, Equations, Mathematical studies, Water storage, Water balance, Hydraulic conductivity.

Drainage from a permeable soil underlain by a coarse-textured layer was investigated. Simplified theory was used to develop a model relating the drainage flux at the base of the soil to the water storage in the soil. Despite significant hysteresis in the water retentivity curve of the overlying soil and in the hydraulic conductivity-pressure potential relationship of the coarse layer, hysteresis had little effect on the storage-flux relation. The model successfully simulated field drainage as measured by a lysimeter and field profile water storage as found by neutron moisture probe measurements. The decline in the drainage flux after the profile has been wetted depends on the depth and retentivity of the soil and the hydraulic conductivity of the underlying coarse layer. To use the model, only simple field measurements to find the storage-flux relationship are needed.

77:02G-066

HOMOVALENT AND HETEROVALENT CATION EXCHANGE EQUILIBRIA IN SOILS WITH VARIABLE SURFACE CHARGE,

Galindo, G.G., and Bingham, F.T.

California University, Department of Soil Science, Riverside, California.

Soil Science Society of America Journal, Vol. 41, No. 5, p 883-886, September-October, 1977. 3 fig, 2 tab, 28 ref.

Descriptors: Cation exchange, Soils, Soil investigations, Sodium, Calcium, Potassium, Magnesium, Adsorption.

Cation-exchange equilibria involving K, Na, Ca, and Mg were studied with Chilean Dystrandepts. The K-Na exchange and the Ca-Mg exchange showed that K and Ca were preferentially adsorbed. Increased charge density through adsorption of phosphate resulted in a reduction in the selectivity for K in the K-Na system. Phosphate adsorption had no apparent effect on the selectivity for Ca in the Ca-Mg system. In heterovalent systems these soils showed a perferential adsorption of the divalent cation. This selectivity was more pronounced at low equivalent concentration of the divalent cation. The selectivity for the divalent cation increased as the surface charge density was increased by phosphate adsorption.

77:02G-067
LEAD ADSORPTION BY MONTMORILLONITE USING A COMPETITIVE LANGMUIR EQUATION,
Griffin, R.A., and Au, A.K.
Illinois State Geological Survey, Department of Geochemistry, Urbana, Illinois 61801.
Soil Science Society of America Journal, Vol. 41, No. 5, p 880-882, September-October, 1977. 4 fig, 10 ref.

Descriptors: Adsorption, Lead, Heavy metals, Clays, Montmorillonite, Soil properties, Soil chemical properties.

The adsorption of Pb from pure Pb(NO3)2 solutions by Ca-montmorillonite at pH 5.00 and 25 degrees C was found to be sensitive to the weight of the clay sample. This apparent sensitivity of the adsorption of Pb to the weight of the sample was attributed to Ca competition for exchange sites as determined from Pb/Ca ratios found in the solutions. Adsorption of Pb from 0.1M Ca(Cl)4)2 solutions was substantially lower and was insensitive to the weight of the clay sample. This further supported our conclusion that adsorption of Pb was dependent on the Pb/Ca ratio.

77:02G-068
ABSENCE OF LOCAL EQUILIBRIUM DURING AMMONIUM TRANSPORT IN A SOIL COLUMN,
Ardakani, M.S., and McLaren, A.D.
California University, Department of Soils and Plant Nutrition, Berkeley, California 94720.
Soil Science Society of America Journal, Vol. 41, No. 5, p 877-879, September-October, 1977. 3 fig, 1 tab, 9 ref.

Descriptors: Adsorption, Ammonium compounds, Soils, Soil investigations, Soil tests, Soil water movement, Sampling, Cation exchange.

Adsorption of HN4(+) from a stationary solution phase by a Hanford soil approached an equilibrium state exponentially after about 30 minutes. By contrast, a local equilibrium did not exist between NH4(+) in a moving solution phase and soil in a column while a 77-ppm NH4(+) - N solution was delivered at a constant flow rate for 26 days. Local equilibrium, however, was established when the downward solution flow was stopped by setting the column horizontally 1 hour before sampling. Thus, the generality of the assumption of instantaneous equilibrium for cations in moving soil solutions is questioned.

77:02G-069
DISSOLUTION OF ARSENIC FROM WATERLOGGED AND AERATED SOIL,
Hess, R.E., and Blanchar, R.W.
California University, Department of Soil Science, Riverside, California 92502.
Soil Science Society of America Journal, Vol. 41, No. 5, p 861-865, September-October, 1977. 1 fig, 1 tab, 16 ref.

Descriptors: Arsenic, Soils, Soil investigations, Soil chemistry, Soil chemical properties, Soil properties.

Sharpsburg and Menfro soils containing 320 and 160 micrograms As/g, respectively, were waterlogged with water or 1% dextrose. The Eh reached a minimum of -150 mV after 1 day of incubation and increased to about +300 mV after 12 days for both soils in 1% dextrose. The Eh remained constant in the Sharpsburg soil during incubation with water, but gradually decreased in the Menfro soil. In the 1% dextrose solution, As increased rapidly in both soils and became constant after 12 days. The As in solution increased more slowly when incubated with water, but also remained constant after 12 days. After freeze-drying and exposing the soil to the atmosphere, Eh increased and As decreased to initial levels.

77:02G-070
THE SHEAR RESISTANCE OF ROOT-PERMEATED HOMOGENEOUS AND STRATIFIED SOIL,
Waldron, L.J.
California University, Department of Soils and Plant Nutrition, Berkeley, California.
Soil Science Society of America Journal, Vol. 41, No. 5, p 843-849, September-October, 1977. 8 fig, 3 tab, 17 ref.

Descriptors: Soils, Soil investigations, Root systems, Root development, Root distribution, Cohesion, Alfalfa, Barley, Model studies.

Mechanical reinforcement which stabilizes soil on slopes has been attributed to plant roots. To measure such reinforcement, direct shear tests were made on 25-cm diameter root-permeated soil columns. Roots of alfalfa, barley, and yellow pine, each increased the shear resistance of homogeneous and compacted layers of silty clay loam at 30-cm depth. One-year-old alfalfa had a much greater reinforcing effect than pine trees 16 months after transplanting or barley at its maximum growth. Barley had a greater effect in the clay loam than pine, but its effectiveness decreased as depth increased from 15 to 30 to 45 cm. Alfalfa roots were more effective than either pine or barley roots in increasing the resistance to shearing between a dense gravel-sand layer (simulating weathered rock) and the overlying soil, increasing shearing resistance to as much as 5 times that of fallow soil. A model is presented of soil reinforced by nonrigid roots. Calculations are given of slope safety factor increases from root reinforcement.

77:02G-071
EFFECT OF MOLE DRAINAGE ON SURFACE RUNOFF FROM A SOIL UNDER PASTURE,
Rennes, A., Tillman, R.W., Syers, J.K., and Bowler, D.G.
Massey University, Department of Soil Science, Palmerston North (New Zealand).
New Zealand Journal of Agricultural Research, Vol. 20, No. 1, p 45-49, February 1977. 2 fig, 2 tab, 12 ref.

Descriptors: Drainage, Drainage systems, Runoff, Pastures, Soil investigations, Mole drains, Soil moisture, Rainfall, Infiltration, Sediments.

The effect of mole drainage on soil moisture and on the movement of water in surface runoff from Tokomaru silt loam under pasture was investigated using two 80 sq m surface runoff plots each of 6 degrees slope. Frequently, particularly during autumn and early winter, surface runoff was reduced on the drained site by between 25 and 50% of that on the undrained site. However, mole drainage was less effective in reducing surface runoff during prolonged rainfall, as in wet winter periods. Under such conditions, there was a reduction both in the differences between infiltration rates and in the infiltration rates themselves for the drained and undrained sites. Regression and correlation analyses suggested that soil moisture was a primary factor influencing surface runoff from the undrained site. In contrast, rainfall intensity and duration were the primary factors influencing surface runoff from the drained site. Greater amounts of sediment were transported in surface runoff from the undrained plot and up to 95% of this sediment was less than 63 micrometers in diameter. Mole drainage had a pronounced effect in reducing the quantity of sediment transported.

77:02G-072
CURRENT TRENDS IN FIELD DRAINAGE PRACTICE,
Green, F.H.W.
Oxford University, Department of Agricultural Science, Parks Road, Oxford, OX1 3PF, United Kingdom.
Journal of Environmental Management, Vol. 5, No. 3, p 207-213, July 1977. 5 fig, 5 ref.

Descriptors: Drainage, Drainage districts, Drainage engineer, Drainage practices, Drainage systems, Drains, Runoff.

To supplement a previous article, particulars are given of current changes in field drainage practice in England and Wales. Presentation is in the form of maps with explanatory text, showing the regional variations in these changes.

77:02G-073
THE MONMOUTHSHIRE LEVELS' DRAINAGE SYSTEM: ITS ECOLOGY AND RELATION TO AGRICULTURE,
Scotter, C.N.G., Wade, P.M., Marshall, E.J.P., and Edwards, R.W.
Wales University Institute of Science and Technology, Department of Applied Biology, Cardiff, S. Glamorgan, Wales.
Journal of Environmental Management, Vol. 5, No. 1, p 75-86, January 1977. 7 fig, 2 tab, 22 ref.

Descriptors: Drainage, Drainage districts, Drainage effects, Drainage practices, Drainage programs, Drainage systems, Agriculture, Crop production, Wildlife habitats, Wildlife conservation, Wildlife.

The Gwent coastal plain or levels is principally an agricultural area. Its 8250 ha are dissected by 1407 km of drainage channels (reens). The type of agriculture practiced, and realization of its full potential, are dependent upon the efficient maintenance of the drainage system. The reens also harbour a rich aquatic flora and fauna. This paper described the evolution of the drainage system, its management and importance to the agriculture of the area. Possible conflicts between progressively efficient agriculture, and the conservation of the reens as a valuable wetland habitat are discussed.

77:02G-074
EXTENSION OF THE SIMILARITY HYPOTHESIS USED FOR MODELING THE SOIL WATER CHARACTERISTICS,
Mualem, Y.
Colorado State University, Engineering Research Center, Fort Collins, Colorado.
Water Resources Research, Vol. 13, No. 4, p 773-780, August 1977. 13 fig, 14 ref.

Descriptors: *Soil water, *Hysteresis, *Soil moisture, *Model studies, Mathematical models, Soils, Wetting, Drying, Curves, Soil physics, Soil physical properties, Soil science.

Two independent domains models were derived by using an extended similarity hypothesis, according to which the pore water distribution function is interpreted to be f(r,rho) = h(r)h(rho). When the hypothesis was applied to the Neel diagram and the Mualem diagram, it yielded 2 different models which permit prediction of the hysteretical relationship from only 1 branch of the main hysteresis loop. The models yield an extremely simple formula for the relationship between the boundary drying and wetting curves. Moreover, a universal nondimensional hysteresis was derived for all soils. Comparison with experiments showed that the model which used the Neel diagram fails to reproduce a reasonable shape of the hysteresis curves. However, much better results were achieved by the second model, which used the Mualem diagram. In some cases the predicted curves were in very good agreement with the observed ones. For soils in which blockage against air entry plays a significant role, the model is less efficient as a predictive tool. It yields poor results in the region of high water content, while the predicted curves are very close to the measured ones in the range of low water content.

77:02G-075
MODELING INFILTRATION DURING A VARIABLE RAIN,
Chu, S.T.
South Dakato State University, Department of Agricultural Engineering, Brookings, South Dakota 57007.
Presented at the 1977 Annual Meeting of the American Society of Agricultural Engineers, June 26-29, 1977, Raleigh, North Carolina, North Carolina State University, p. 1-14. 1 fig, 2 tab, 6 ref, 45 equ.

Descriptors: Model studies, Infiltration, Rainfall, Rainfall intensity, Rainfall-runoff relationships.

The Green Ampt equation was modified to describe the infiltration process during a rainfall event with variable intensities. A procedure was introduced to determine the volume of runoff and the distribution of rainfall excess.

77:02G-076
AIR-EARTH INTERFACE CONCEPT FOR WIDE-RANGE CONTROL OF INFILTRATION,
Dixon, R.M.
United States Department of Agriculture, Agricultural Research Service, Southwest Rangeland Watershed Research Center, Tucson, Arizona.
Presented at the 1977 Annual Meeting of the American Society of Agricultural Engineers, June 26-29, 1977, Raleigh, North Carolina, North Carolina State University, p. 1-33. 11 fig, 1 tab, 28 ref.

Descriptors: Infiltration, Soil water movement, Simulation analysis, Soils, Soil investigations.

The air-earth interface concept is formulated and discussed relative to experimental verification, compatibility with Darcy-based infiltration theory, quantification for predictive purposes, and applicability to practical infiltration control problems. This concept appears applicable to cultivated and uncultivated soils, and to soils severely disturbed by road construction and strip mining.

77:02G-077
SOLUTE TRANSFER, WITH EXCHANGE BETWEEN MOBILE AND STAGNANT WATER, THROUGH UNSATURATED SAND,
Gauden, J.P., Jegat, H., Vachaud, G., and Wierenga, P.J.
Centre National de la Recherche Scientifique, Paris (France).
Soil Science Society of America Journal, Vol. 41, No. 4, p 665-671, July-August, 1977. 6 fig, 2 tab, 22 ref.

Descriptors: *Solutes, *Transfer, *Ion exchange, Unsaturated flow, Diffusion, Soils, Salinity, Depth, Leaching, Laboratory tests, Numerical analysis, Mathematical models, Equations, Stagnant water, Calcium chloride.

Changes in salt concentration with time were measured at several depths inside and at the exit of a 94-cm uniform unsaturated sand column which was leached at steady rates with solutions of calcium chloride. Observed salt distributions were compared with salt distributions calculated with a numerical procedure which was based on the dead-end pore model of Coats and Smith (1964). Values for the dispersion coefficient, the diffusional mass transfer coefficient, and the fraction mobile water used in the model were obtained at different water contents by curve fitting observed and calculated concentrations at one depth. The same values then were used to calculate salt distributions at other depths and at the exit of the column and were compared with measured salt distributions. Excellent agreement was obtained. The model presented a good description of the extensive tailing of the salt concentration distributions observed inside and at the exit of the column. The amount of stagnant water was found to increase with decreasing water content from 4% of the total water content of 0.256 cu cm/cu cm to 40% of the total water content at a water content of 0.200 cu cm/cu cm. The apparent dispersion coefficient decreased from 6 sq cm/hour to 1 sq cm/hour at water contents of 0.256 and 0.200 cu cm/cu cm, respectively.

77:02G-078
KINETICS OF SALT RELEASE FROM A SALINE SOIL,
Jurinak, J.J., Whitmore, J.C., and Wagenet, R.J.
Utah State University, Department of Soil Science and Biometeorology, Logan, Utah.
Soil Science Society of America Journal, Vol. 41, No. 4, p 721-724, July-August, 1977. 5 fig, 8 ref.

Descriptors: *Saline soils, *Utah, *Water quality, *Soil chemical properties, *Leaching, *Salinity, *Kinetics, *Salts, Diffusion, Analytical techniques, Percolation, Soil moisture, Soil water, Soil water movement, Physical properties, Properties, Saline water.

The kinetics of salt release from simulated saline sediments were studied to ascertain the potential of sediments as a diffuse source of salinity. Two rate equations were derived, both based on the premise that dissolution is a diffusion controlled process. The equations were ln(1-C/C sub s) = -kt and C = k't(1/2), where c is the concentration at any point in the bulk solution, c sub s is the equilibrium concentration of the soluble soil minerals, t is time, k is the first-order rate constant, and k' a proportionality constant. Kinetic data were obtained from a saline typic torriorthent soil derived from Mancos shale in the Price River Basin, Utah. During the initial 72 hours of reaction, dissolution can be described by three diffusion controlled reactions. Increasing particle size decreased the rate of reaction. Both derived equations were equally effective in describing salt release.

77:02G-079
EFFECT OF SOIL STRENGTH ON SOIL DETACHMENT DUE TO RAINDROP IMPACT,
Cruse, R.M., and Larson, W.E.
Minnesota University, St. Paul, Minnesota.
Soil Science Society of America Journal, Vol. 41, No. 4, p 777-781, July-August, 1977. 7 fig, 3 tab, 18 ref.

Descriptors: *Raindrops, *Soil strength, *Impact (rainfall), Erosion, Shear strength, Sheet erosion, Bulk density, Soils, Mathematical studies, Equations.

Soil strength was altered in 3 different ways to test the hypothesis that soil splash from raindrop impact is related to soil strength parameters. Bulk density changes were used to alter direct solid particle-to-particle contact; changes in matric potential were used to change contact relationships between solid particles and liquid films; and additions of polyvinyl alcohol (PVA) provided a direct bonding mechanism between solid particles. The amount of soil detached by a single simulated 4.8-mm raindrop falling from a height of 177 cm was correlated closely with the shearing strength as measured by a triaxial compression test.

77:02G-080
ANALYSIS OF THE SATURATED-UNSATURATED HYDRAULIC CONDUCTIVITY IN A MIXED SODIUM-CALCIUM SOIL SYSTEM,
Russo, D., and Bresler, E.
Volcani Institute of Agricultural Research, Bet-Dagan (Israel).
Soil Science Society of America Journal, Vol. 41, No. 4, p 706-710, July-August, 1977. 4 fig, 23 ref.

Descriptors: *Hydraulic conductivity, *Ions, *Sodium, *Calcium, Soils, Soil water movement, Montmorillonite, Pore pressure, Pores, Porosity, Soil properties, Model studies, Mathematical models, Soil science.

A model was developed to diagnose the effects of Na/sq rt of Ca ratios and soil solution concentrations on the hydraulic conductivity for an unsaturated soil. The model takes into account the porous nature and the electrical properties of the soil. Interactions between ions in the exchange phase and in the liquid phase were expressed quantitatively by the diffuse double-layer theory. Experimental data on the effect of soil solution and soil water pressure on clay platelet organization and structure were considered in the model. A test was made on the sensitivity of the model to variations in the various input parameters. The model was found to be sensitive to the relationship between the number of platelets per clay particle and the ESP of the soil. The diagnostic model was compared with experimental data for 3 soils of different texture. The model approximates the hydraulic conductivity function for many practical combinations of Na/sq rt of Ca ratios and soil solution concentrations for the ranges of soil water content in which most of the water flow occurs.

77:02G-081
EFFECT OF MIXED NA-CA SOLUTIONS ON THE HYDRAULIC PROPERTIES OF UNSATURATED SOILS,
Russo, D., and Bresler, E.
Volcani Institute of Agricultural Research, Bet-Dagan (Israel).
Soil Science Society of America Journal, Vol. 41, No. 4, p 713-717, July-August, 1977. 6 fig, 1 tab, 20 ref.

Descriptors: *Sodium, *Calcium, *Soil properties, *Hydraulic properties, Soil water, Unsaturated flow, Loam, Soils, Ion exchange, Diffusivity, Hydraulic conductivity, Moisture content, Laboratory tests, Retention.

The effects of mixed Na-Ca solutions on soil water diffusivity and unsaturated hydraulic conductivity were tested for a loamy soil from Gilat, Israel. Soil water diffusivity functions, D(theta), were determined by the horizontal infiltration method. Unsaturated hydraulic conductivity functions, K(theta), were determined both directly (by vertical infiltration for suction heads of 0-50 cm H_2O) and indirectly (from diffusivity functions and soil water retention curves). Prior to determinations, soil samples were equilibrated with solutions containing a given concentration and composition of Ca and Na. The results showed that D(theta) and K(theta) are independent of solution concentrations in a Ca-saturated system. In mixed Na-Ca systems, hydraulic conductivity and soil water diffusivity functions are highly dependent on the composition and concentration of the soil solution, in addition to their dependence on soil water content, theta. For any given theta, both K(theta) and D(theta) decrease as either soil solution concentration decreases or the sodium fraction in the soil solution increases. The negative effect of a combination of high Na-to-Ca ratio and low soil solution concentration on K(theta) is related directly to the degree of water saturation of the soil. Low values of theta can compensate for the negative effects of high Na-to-Ca ratio and low solution concentration.

77:02G-082

CHISELING INFLUENCES ON SOIL HYDRAULIC PROPERTIES,

Allmaras, R.R., Rickman, R.W., Ekin, L.G., and Kimball, B.A.
Agricultural Research Service, Columbia Plateau Conservation Research Center, Pendleton, Oregon.
Soil Science Society of America Journal, Vol. 41, No. 4, p 796-803, July-August, 1977. 7 fig, 2 tab, 26 ref.

Descriptors: *Chiselling, *Oregon, *Washington, *Soil water, *Infiltration, *Hydraulic conductivity, Cultivation, Soil properties, Silts, Loam, Cation exchange, Clays, Organic matter, On-site investigations, Bulk density, Depth, Moisture content, Drainage, Evaporation, Hydraulic properties.

Hydraulic conductivity (K) and soil water desorption characteristic (SWDC) were field measured in the 120-cm soil profile of a Walla Walla (Mesic type Haploxeroll) silt loam before and after chiselling 43-cm deep. The test Walla Walla soil is layered. Chiselling affected both the SWDC and K in the upper 30 cm, especially at 10 and 20-cm depths, but had no influence on the measurements at increased, especially in the -50 to -300 mbar range. Failure of chiselling to improve water relations in the mild duripan extending from 30 to 45 cm suggests the need for addition of plant residue or chemical amendments into the chisel slots. Water contents and hydraulic heads during drainage showed that chiselling could reduce evaporation by reducing water content and diffusivity. Overall soil profile hydraulic resistances showed relative average K up to 15 times greater as a result of chiselling 43 cm deep, but nearly similar accelerated internal drainages were projected for simulated chiselling to 25-cm depth vs. chiselling to 43 cm.

77:02G-083

A LABORATORY TECHNIQUE FOR APPRAISING IN SITU SALINITY OF SOIL,

Mubarak, A., and Olsen, R.A.
Montana State University, Department of Chemistry, Bozeman, Montana.
Soil Science Society of America Journal, Vol. 41, No. 5, p 1018-1020, September-October, 1977. 2 fig, 2 tab, 14 ref.

Descriptors: *Saline soils, *Salinity, *Electrical conductance, *Laboratory tests, Centrifugation, Chemistry, Salts, Analytical techniques, Soils, Soil properties, Immiscibility, Soil science, Soil solutions, Dilution effects.

A laboratory technique was devised for removal of solution from soils at field water content. A soil sample can be placed directly in a closable centrifuge tube, thereby minimizing changes which could be induced by altering gaseous equilibria. Water need not be added to the soil sample, so changes in electrical conductivity (EC) and in concentration of species present are avoided. The soil solution was obtained from the sample by immiscible displacement with carbon tetrachloride using centrifugation. The technique is simple and relatively rapid. Values for EC in successively displaced solution samples from a given soil sample were found to be essentially constant. The values for EC obtained for an assortment of soils were significantly higher than those obtained using 2:1 or saturation extracts but were well correlated with them.

77:O2G-084

THE SOLUBILITIES OF CARBONATES AND PHOSPHATES IN CALCAREOUS SOIL SUSPENSIONS,

Marion, G.M., and Babcock, K.L.
Weyerhaeuser Forestry Research Center, 505 North Pearl Street, Centralia, Washington 98531.
Soil Science Society of America Journal, Vol. 41, No. 4, p 724-728, July-August, 1977. 4 fig, 6 tab, 36 ref, 2 equ.

Descriptors: Soils, Soil investigations, Carbonates, Phosphates, Ions, Soil chemistry.

Previously reported discrepancies between measured soil carbonate and phosphate activity products and the solubility products of pure crystalline minerals may, in part, be attributable to the incomplete characterization of ion-pairs in solution. Up to 50 percent of the soluble PO4 and significant amounts of Ca, Mg, and SO4 were present as ion-pairs. Ignoring ion-pairs resulted in significant differences in calculated activity products for both carbonates and phosphates. One soil was undersaturated and two were supersaturated with respect to calcite. Calcite was the only carbonate mineral identified by X-ray diffraction measurements. Calcium carbonate activity products were highly correlated to Mg activities. Magnesium-calcite apparently controlled the solubility of soil carbonate. The soil phosphate activity products fell between the solubility products of octacalcium phosphate and hydroxyapatite. The phosphate solubility data were compatible with, but not proof of, the presence of calcium phosphate minerals in soils.

77:O2G-085

OXIDATION OF ELEMENTAL SULFUR IN SOILS,

Nor, Y.M., and Tabatabai, M.A.
Sains Malaysia University, School of Biological Sciences, Penang, Malaysia.
Soil Science Society of America Journal, Vol. 41, No. 4, p 736-741, July-August, 1977. 5 fig, 4 tab, 25 ref.

Descriptors: Oxidation, Sulfur, Soils, Soil investigations, Soil chemistry.

Studies of oxidation of elemental S in soils showed that thiosulfate and tetrathionate are produced during S oxidation in soils. In this work, unamended and elemental S-amended soils were incubated (30 degrees C) under aerobic conditions for various times. The amounts of S2O3-, S4O6-, and SO4-S produced during incubation were determined. Results showed that S2O3(2-) was produced within the first few days of incubation and that S4O6(2-) accumulated in some soils. The rate of S oxidation increased with increasing incubation temperature (5, 15, and 30 degrees C) and with increasing the rate of S application (50, 100, and 200 micrograms S/gram soil). For 100 micrograms S/gram soil, the rates of oxidation of elemental S in 10 Iowa surface soils ranged from 39 to 75 micrograms S/gram soil after incubation at 30 degrees C for 70 days; rates were more rapid in alkaline soils than in acid soils. There was little change in pH of soils even when the S application rate was increased from 50 to 200 micrograms S/gram soil. The rate of S oxidation was lower in air-dried soils than in field-moist soils.

77:O2G-086

ADSORPTION OF ZN BY FE AND AL HYDROUS OXIDES AS INFLUENCED BY AGING AND PH,

Shuman, L.M.
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Soil Science Society of America Journal, Vol. 41, No. 4, p 703-706, July-August, 1977. 4 fig, 1 tab, 15 ref.

Descriptors: Adsorption, Zinc, Iron.

Zinc solutions were equilibrated with both fresh and aged Fe and Al hydrous oxides to measure Zn adsorption. The data conformed to the Langmuir isotherm and the Langmuir coefficients for Zn adsorption capacities and bonding energies were determined. The adsorption capacities for the aged Fe oxide (geothite) and the aged Al oxide (gibbsite) were the same. The adsorption capacities for both of the fresh oxides (amorphous) were about 10 times those for the aged oxides which corresponded to a 10-fold difference between their respective CEC's and surface areas.

The bonding energies for Zn for the fresh Al oxide were three times that for the fresh Fe oxide but the bonding energies for the two aged oxides were the same. Bonding energies were directly related to adsorption capacities. The inflection points on the Zn adsorption vs. pH curves were between pH 5 and 6 for both oxides.

77:02G-087
SOIL TYPES AND INFILTRATION/WATER MOVEMENT,
Bree, J.
Agrifim Irrigation, Incorporated, 6948 Arrowwood Drive, Modesto, California 95355.
Drip/Trickle Irrigation, Vol. 2, No. 2, p 18-19, 29, March-April, 1977. 2 fig, 1 tab.

Descriptors: Irrigation systems, Irrigation practices, Soils, Infiltration, Soil water, Soil water movement, Soil moisture, Irrigation design.

With drip irrigation, watering the crop rather than the soil is discussed. However, soils are of major importance to the agronomist, because they are his primary concern in the selection of equipment and the design of a drip/trickle system.

77:02G-088
INFLUENCE OF EXCHANGEABLE CATION ON THE SORPTION OF TRACE AMOUNTS OF CADMIUM BY MONTMORILLONITE,
Garcia-Miragaya, J., and Page, A.L.
Instituto Venezolano de Investigaciones Cientificas, Centro de Ecologia, Apdo 1827, Caracas 101, Venezuela.
Soil Science Society of America Journal, Vol. 41, No. 4, p 718-721, July-August, 1977. 2 fig, 2 tab, 20 ref.

Descriptors: Cation exchange, Sorption, Cadmium, Clays, Soil water, Soil moisture.

The effect of different exchangeable cations on the sorption of trace amounts of Cd by montmorillonite (clay fraction, Upton, Wyoming) was studied by equilibrating samples of homoionic clay suspensions with CdCl2 solutions ranging from 15 to 120 micrograms Cd/liter. These Cd concentrations are similar to those found in natural and contaminated soil-water systems. The amount of Cd sorbed on the montmorillonite surfaces depended on the kind of exchangeable cation, decreasing in the order Na-montmorillonite > K-montmorillonite > Ca-montmorillonite > Al-montmorillonite. Exchangeable Al was found to be particularly effective in reducing Cd sorption by high energy sites on montmorillonite.

77:02G-089
EFFECT OF INORGANIC AND ORGANIC COMPOUNDS ON THE EXTRACTABILITY OF 239PU FROM AN ARTIFICIALLY CONTAMINATED SOIL,
Nishita, H., Haug, R.M., and Rutherford, T.
California University, Laboratory of Nuclear Medical and Radiation Biology, Los Angeles, California.
Journal of Environmental Quality, Vol. 6, No. 4, p 451-455, October-December, 1977. 1 fig, 4 tab, 32 ref.

Descriptors: Soils, Soil investigations, Organic matter, Soil tests, Soil properties, Soil chemistry.

The effect of a number of inorganic and organic compounds on the extractability of 239Pu from a contaminated soil has been examined. This has been done on an artificially contaminated kaolinitic soil by using the equilibrium batch method of extraction. Among the 21 inorganic compounds examined, NaHP04 showed the least 239Pu extractability (0.07% of dose) and Na4P207 showed the greatest extractability (28.59% of dose). The compounds that showed relatively high 239Pu extractability included NaF, Na2B407, Na4P207, Na2C03, Na202, NaOH, and NH4OH. Among the organic compounds, the order of 239Pu extractability was Na acetate less than Na formate less than Na oxalate less than Na tartrate less than Na citrate. A 0.004M DTPA solution was a more effective extractant than a 0.08M citric acid solution. Aside from the chemical nature of these compounds, the 239Pu extractability was influenced by soil and extractant pH, soil organic matter, equilibrium time, soil weight/extractant volume ratio, and wet-dry pretreatment of the soil.

77:02G-090
ABIOLOGICAL METHYLATION OF MERCURY IN SOIL,
Rogers, R.D.
United States Environmental Protection Agency, Monitoring and Support Laboratory,
Office of Research and Development, Las Vegas, Nevada 89114.
Journal of Environmental Quality, Vol. 6, No. 4, p 463-467, October-December, 1977.
3 fig, 3 tab, 11 ref.

Descriptors: Soils, Soil investigations, Heavy metals, Mercury, Organic matter, Soil chemistry.

The results from this work define several factors influencing the methylation of mercuric ion in soil. Two of the most important findings were that it is possible to extract the mercury methylating factor from soil with a solution of 0.5N sodium hydroxide (NaOH) and that this factor is responsible for the abiological methylation of Hg in the soils under investigation. The ability of the soil extract to methylate Hg is influenced by temperature, mercuric ion concentrations, and solution pH. In addition, it was found that the methylating ability of the soil extract was stable at high temperatures (121C), but was lost after exposure to ultraviolet radiation.

77:02G-091
TEMPERATURE GRADIENT EFFECTS ON IN SITU HYGROMETER MEASUREMENTS OF WATER POTENTIAL,
Wiebe, H.H., Brown, R.W., and Barker, J.
Utah State University, Department of Soil Science, Logan, Utah 84322.
Agronomy Journal, Vol. 69, No. 6, p 933-939, November-December, 1977. 6 fig, 1 tab,
17 ref.

Descriptors: Temperature, Hygrometry, Soil water, Soil moisture, Soil properties, Soils.

The effects of temperature gradients on water potential measurements with various commercial and laboratory soil hygrometers were tested in a soil column at -18 bars or in a sponge column wetted with a -18 bar sodium chloride solution. Temperature gradients were induced in the medium by warming or cooling either the base or the top of the column for several hours. Hygrometers in which the measuring (wet) junction was located in the middle of the cylindrical sample surface gave small temperature gradient errors, less than 3 bars when the temperature gradient in the surrounding medium was 1 degree cm(-1). Locating the measuring thermocouple near the base of the cylindrical sample surface gave errors ranging from 10 to 18 bars per gradient for 1 degree cm(-1). Hygrometers with an "end window" sample surface gave errors ranging from 23 to 62 bars. Water potential readings were consistently too low (dry) when the sample surface was cooler than the measuring junction, and too high (near zero) when the sample surface was warmer. Accurate water potentials were obtained with all models when medium temperature was uniform.

77:02G-092
THE MINIMUM SIZE OF PERMEABLE FILL USED WITH MOLE DRAINAGE,
Dennis, C.W., and Groote, S.G.
Ministry of Agriculture, Field Drainage Experimental Unit, Fisheries and Food,
Anstey Hall, Trumpington, Cambridge, Great Britian.
Agricultural Water Management, Vol. 1, No. 2, p 143-153, September 1977. 7 fig,
1 tab, 6 ref.

Descriptors: Mole drainage, Drainage engineering, Drainage practices, Drainage systems, Drains, Hydraulic conductivity.

Laboratory work involving the full scale simulation of flow from a mole drainage channel into a trench filled with permeable material and thence to the pipe drain at the bottom of the trench is described. Four sizes of permeable fill, two trench widths, two pipe types and a wide range of flow rates were used in the investigations. Provided that there was reasonable vertical separation between the mole channel and pipe the flow could be divided into three distinct phases namely; entry from the mole channel, near vertical flow within the permeable fill and entry into the pipe. The most limiting of these was the ability of the fill to accept water from the mole channel. Variation of hydraulic head with flow rate and permeable fill size at critical points of the system is presented in graphical form. It is suggested that permeable fill with a mean diameter of 5 mm is the minimum size acceptable under United Kingdom conditions and that this result will not be affected by the presence of a small quantity of fine material. The hydraulic conductivity associated with such material, in the absence of fines, is approximately 2500 m/day. Application of the data to other design conditions is also possible.

77:02G-093
PARAMETER ESTIMATION OF THE GREEN AND AMPT INFILTRATION EQUATION,
Brakensiek, D.L., and Onstad, C.A.
United States Department of Agriculture, Agricultural Research Service, Northwest Watershed Research Center, Boise, Idaho 83701.
Water Resources Research, Vol. 13, No. 6, p 1009-1012, December 1977. 2 fig, 5 tab, 10 ref, 4 equ.

Descriptors: Infiltration, Soil water, Soil water movement, Watersheds, Runoff, Hydrology.

Infiltrometer data are utilized to test a fitting procedure for the Green and Ampt infiltration equation parameters. The spatial variation of the estimated parameters is averaged to give lumped parameter values for watershed modeling. An appropriate scale for parameter averaging is discussed, which transforms parameter values to normal deviates. A sensitivity analysis for the equation parameters is performed for both infiltration estimates and runoff hydrograph volume and peak rates. The capillary pressure parameter shows least sensitivity; however, variation in the fillable porosity and effective conductivity parameters has a major influence on infiltration and runoff amounts and rates.

77:02G-094
INFLUENCE OF THE HYSTERESIS EFFECT ON TRANSIENT FLOWS IN SATURATED-UNSATURATED POROUS MEDIA,
Hoa, N.T., Gaudu, R., and Thirriot, C.
Institute of Fluid Mechanics, Toulouse, France.
Water Resources Research, Vol. 13, No. 6, p 992-996, December 1977. 5 fig, 7 ref, 2 equ.

Descriptors: Hysteresis, Saturated flow, Porous media, Soil water, Soil water movement, Unsaturated flow, Simulation analysis.

In the following report the authors experimentally and numerically study one- and two-dimensional transient flows where the hysteresis of the relationship of suction-water content clearly appears. In the numerical simulation of these flows, by using a finite element method, the hysteresis effect is taken into account by considering both its primary and secondary scanning curves; when the seepage surface occurs, it too is taken into account. The comparison with experimental results shows that in the concerned problems a numerical simulation in which this hysteresis effect is ignored may involve important errors.

77:02G-095
INFILTRATION FORMULA BASED ON SCS CURVE NUMBER,
Aron, G., Miller, A.C., Jr., and Lakatos, D.F.
Pennsylvania State University, Department of Civil Engineering, University Park, Pennsylvania.
Journal of the Irrigation and Drainage Division, American Society of Civil Engineers, Vol. 103, No. IR4, Proceedings Paper 13427, p 419-427, December 1977. 3 fig, 4 tab, 9 ref.

Descriptors: *Infiltration, *Rainfall-runoff relationships, *Runoff, *Model studies, Soils, Storms, Urbanization, Equations, Curves, Permeability, Storage capacity, Soil water, Urban runoff, Differentiation.

A formula was developed for computing infiltration in rainfall-runoff simulations from published Soil Conservation Service (SCS) soils data. Cumulative infiltration was treated as the difference between cumulative rainfall and runoff. The SCS runoff formula then was differentiated with respect to precipitation to arrive at an infiltration rate with respect to rainfall increments rather than time as is used in most previous formulas. A numerical example was included, and 2 possible refinements were suggested which would involve additional computational labor but should improve the infiltration simulation.

77:02G-096
PROTECTION OF A UNIQUE ECOLOGICAL AREA THROUGH IMPROVED WATER AND FERTILITY MANAGEMENT,
Fischbach, P.E.
Nebraska University, Department of Agricultural Engineering, Lincoln, Nebraska.
Available from the National Technical Information Service, Springfield, Virginia 22161 as PB-274 399. University of Nebraska Water Resources Center, Completion Report, October 2, 1977. 187 p, 68 fig, 43 tab, 7 ref, 4 append.

Descriptors: *Water management (applied), *Soil properties, *Nitrogen, *Water utilization, *Nitrates, *Leaching, *Fertilization, *Nebraska, Model studies, Irrigation, Sands, Corn (field), Soil water, Moisture deficit, Evapotranspiration, Percolation, Rainfall, Fertilizers, Crop production, Soil-water-plant relationships.

Research was conducted to define practices for managing water and nitrogen fertilizer in the production of irrigated corn on sandy soils. The objective was to increase the efficiency of use of the water resource while minimizing the leaching of nitrate nitrogen from the crop root zone to the groundwater system. On the sandy soils which were studied, experiments showed that it is not necessary to completely replenish the soil water deficit at each irrigation. Near maximum yields were obtained when water application was limited to an amount equivalent to .76 cm per day, approximately 60% of the peak evapotranspiration rate. Stored soil water and rainfall supplemented irrigation application. Percolation loss was minimized by this technique. An irrigation frequency of 3.5 days during July and August produced greater yields than did frequencies of 1.5 or 7 days. Research indicated that the present farmer practice of applying 250 kg/ha of nitrogen and completely replenishing the soil water deficit at each irrigation may result in nitrate leaching losses of 30 to 45 kg/ha during the growing season, depending on rainfall amount.

77:02G-097
COLORIMETRIC DETERMINATIONS OF EXCHANGEABLE AMMONIUM, UREA, NITRATE, AND NITRITE IN A SINGLE SOIL EXTRACT,
Onken, A.B., and Sunderman, H.D.
Texas A and M University, Agricultural Experiment Station, Agricultural Research Extension Center, Lubbock, Texas.
Agronomy Journal, Vol. 69, No. 1, p 49-53, January-February, 1977. 10 tab, 9 ref.

Descriptors: Ammonium, Urea, Nitrates, Nitrites, Fertilizers, Soils, Soil investigations, Soil tests.

Interest in N transformations in soils has increased greatly in recent years, particularly with increased use of urea-containing fertilizers. However, only one procedure for determination of exchangeable ammonium, nitrate, nitrite, and urea in a single soil extract has been proposed and it requires the use of both distillation and colorimetric equipment. It would be useful to have a set of colorimetric procedures for the determination of these N forms in a single extract. Previous research indicated sodium sulfate, as an extractant, would be least likely to produce unwanted interferences in these procedures. Thus, research was initiated to determine (i) if Na2SO4 could be used as an extractant for exchangeable NH4+, NO3-, NO2- and urea and (ii) necessary modifications to make desirable colorimetric procedures usable in a Na2SO4 extraction system.

77:02G-098
EFFECT OF SELECTIVE DISSOLUTION, ELECTROLYTES, AERATION, AND STERILIZATION ON TECHNETIUM-99 SORPTION BY SOILS,
Landa, E.R., Thorvig, L., and Gast, R.G.
Oregon State University, Department of Soil Science, Corvallis, Oregon 97331.
Journal of Environmental Quality, Vol. 6, No. 2, p 181-187, April-June, 1977.
7 fig, 2 tab, 24 ref.

Descriptors: Soils, Soil investigation, Sorption, Soil chemistry, Soil chemical properties, Anion exchange, Organic matter.

The objective of this study was to determine the extent that technetium-99, a long-lived beta-emitting radionuclide, might be sorbed from aqueous solution by 11 well-characterized soils, and to elucidate the sorption mechanisms involved. About 98% of the added 99Tc was sorbed within a period of 2 to 5 weeks by 8 of the 11 soils. The slow kinetics observed and the removal of trace quantities of 99Tc from solution in the presence of large amounts of chloride and phosphate tend to rule out anion exchange as the sorption mechanism. The lack of sorption exhibited by the low organic matter soils, the reduction in sorption following H_2O_2 digestion of the soil, and the high recoveries of sorbed 99Tc on extraction with NaOH suggest a role for the living and/or nonliving organic fraction of the soil. Sterilization of previously sorbing soils eliminated the sorption ability, indicating a microbial role in the process. Results of aeration experiments were ambiguous but suggest that anaerobic conditions are not a prerequisite for 99Tc sorption by soils.

77:02G-099
DECOMPOSITION OF RICE STRAW IN SOILS AS AFFECTED BY SOME MANAGEMENT FACTORS,
Sain, P., and Broadbent, F.E.
California University, Department of Land, Air, and Water Resources, Davis, California 95616.
Journal of Environmental Quality, Vol. 6, No. 1, p 96-100, January-March, 1977.
6 fig, 3 tab, 18 ref.

Descriptors: Rice, Decomposing organic matter, Soils, Soil investigations, Laboratory tests, Nitrogen, Phosphorus, Soil properties, Sulfur.

Decomposition of rice straw contained in nylon bags was measured in field experiments at two different locations during winter and spring months. Incorporated straw decomposed more rapidly than did straw on the soil surface, and least decomposition occurred in straw samples suspended above the soil surface as in a windrow. Decomposition rates were not affected by chopping straw. Laboratory decomposition experiments conducted at 8 and 25C and at 60 and 150% water holding capacity showed more effect of low temperature in retarding straw decomposition than excess water. Additional nitrogen stimulated straw decomposition in Stockton adobe clay during the first few weeks but had little effect in Sacramento clay. After 2 months' initial decomposition the soil samples treated with straw were dried and rewetted to 60% water holding capacity (WHC), then incubated another 2 months. During this period straw decomposition in Sacramento clay samples which had received additional N was significantly depressed. Additional P and S had no effect on rice straw decomposition.

77:02G-100
MASSIVE ACCUMULATION OF CALCIUM CARBONATE AND ITS RELATION TO NITROGEN FIXATION OF SAINFOIN,
Ross, W.D., and Delaney, R.H.
Wyoming University, Plant Science Division, Laramie, Wyoming 82071.
Agronomy Journal, Vol. 69, No. 2, 0 242-246, March-April, 1977. 2 fig, 3 tab, 25 ref.

Descriptors: Lagoons, Calcium carbonate, Nitrogen, Soils, Soil investigations.

Sainfoin has many desirable qualities as a legume forage, but it is not widely grown because of its lack of persistence and poor N-fixation on many sites. The effect of competition by non-N-fixing soil microorganisms on N-fixation was studied at 0, 50, 80, 95, and 100% levels of autoclaved soil sterilization. Plants were grown aseptically for 30 days, dipped in Rhizobium inoculum, and transplanted to the sterilized soil. After 47 and 87 days in the growth chamber at 24/18 C, the plants were harvested. Nitrogen fixation was determined by the acetylene reduction capacity of the complete root system. Unexpectedly, root distortion accompanied by massive accumulation of $CaCO_3$ was stimulated in sainfoin roots that were grown in autoclaved soil to reduce the soil microorganisms. The purpose of the data presented is to describe the accumulation of Ca and its affect on N-fixation in sainfoin.

77:02G-101
ANION MOBILITY IN SOILS: RELEVANCE TO NUTRIENT TRANSPORT FROM TERRESTRIAL TO AQUATIC ECOSYSTEMS,
Johnson, D.W., and Cole, D.W.
Washington University, College of Forest Resources, Washington.
Publication No. EPA-600/3-77-068, June 1977. 27 p, 8 fig, 1 tab, 50 ref, 1 append.

Descriptors: Nutrients, Soil chemistry, Ions, Anions, Adsorption, Leaching, Model studies.

Nutrient transport from terrestrial to aquatic ecosystems is strongly mediated by soil chemical interactions. Ions deposited on or biologically released within the soils can enter into a variety of exchange and precipitation reactions prior to (or instead of) entering aquatic ecosystems. This report reviews the current knowledge of soil anion adsorption reactions and their effects on leaching, and suggests a simple model, based on anion production and adsorption considerations, to predict and explain nutrient transport. The relationship of this approach to that based on cation production and adsorption is discussed.

77:02G-102
PLUTONIUM UPTAKE BY PLANTS FROM SOIL CONTAINING PLUTONIUM 238 DIOXIDE PARTICLES,
Brown, K.W., and McFarlane, J.C.
Monitoring Systems Research and Development Division, Environmental Monitoring and Support Laboratory, Las Vegas, Nevada 89114.
Publication No. EPA-600/3-77-052, May 1977. 13 p, 3 fig, 2 tab, 21 ref.

Descriptors: Alfalfa, Vegetables, Crop production, Soil investigations, Plutonium, Soil chemistry.

Three plant species--alfalfa, lettuce, and radishes--were grown in soils contaminated with plutonium-238 dioxide (238Pu02) at concentrations of 23, 69, 92, and 342 nanocuries per gram (nCi/g). The length of exposure varied from 60 days for the lettuce and radishes to 358 days for the alfalfa. The magnitude of plutonium incorporation as indicated by the discrimination ratios for these species, after being exposed to the relatively insoluble Pu02, was similar to previously reported data using different chemical forms of plutonium. Evidence indicates that the predominant factor in plutonium uptake by plants may involve the chelation of plutonium contained in the soils by the action of compounds such as citric acid and/or other similar chelating agents released from the plant roots.

77:02G-103
FIELD MEASUREMENT OF DENITRIFICATION,
Rolston, D.E., and Broadbent, F.E.
California University, Department of Land, Air and Water Resources, Davis, California 95616.
Publication No. EPA-600/2-77-233, November 1977. 75 p, 40 fig, 15 tab, 13 ref.

Descriptors: Denitrification, Leaching, Return flow, Water quality, Irrigation, Irrigation effects, Nitrogen, Nitrification, Nitrates.

The proportion of volatile products and rates of denitrification as influenced by field-soil environmental conditions can only be ascertained by measuring the flux of the gases produced. A thorough, quantitative evaluation of the rate and magnitude of denitrification, leaching, and plant uptake provides a means for making management decisions to control irrigation return flow water quality.

77:02G-104
IMMOBILIZATION OF FERTILIZER NITRATE APPLIED TO A SWELLING CLAY SOIL IN THE FIELD,
Kissel, D.E., Smith, S.J., Hargrove, W.L., and Dillow, D.W.
Texas Agricultural Experiment Station, Temple, Texas 76501.
Soil Science Society of America Journal, Vol. 41, No. 2, p 346-349, March-April, 1977. 2 fig, 1 tab, 18 ref.

Descriptors: Nitrogen, Fertilizers, Fertilization, Nutrients, Crop production, Soil properties, Soil texture, Crop response, Immobilization, Sorghum, Clays, Nitrogen, Soil temperature.

Low recoveries of N fertilizer by crops on Houston Black clay prompted this investigation. Our objectives were to determine how much fertilizer nitrate can be biologically immobilized under field conditions when fertilization exceeds crop requirements and to determine when immobilization occurs during the growing season. Calcium nitrate tagged with 9.6 atom % 15N was applied to field microplots at 328 kg N/ha and grain sorghum was planted in rows across each microplot. The various components of the N balance were measured by sampling microplots at different times during the season. Only 2.1 kg N/ha was immobilized during the first 47 days after fertilization and planting. The rate of immobilization increased rapidly during the next 60 days and an additional 60 kg N/ha was immobilized. This increase was apparently in response to an increase in soil temperature above 22 C.

77:02G-105
ASSESSING TWO DIAGNOSTIC METHODS FOR ENUMERATION OF NITRATE REDUCING AND DENITRIFYING BACTERIA IN SOIL-PLANT ROOT ASSOCIATIONS,
Volz, M.G.
Connecticut Agricultural Experiment Station, New Haven, Connecticut 06504.
Soil Science Society of America Journal, Vol. 41, No. 2, p 337-340, March-April, 1977. 4 tab, 14 ref.

Descriptors: Nitrates, Denitrification, Bacteria, Soils, Soil investigations, Soil chemistry, Fertilizers, Fertilization, Tomatoes, Soybeans, Corn.

Most probable number (MPN) determinations were made of NO3(-) reducing-and denitrifying bacteria in soil samples taken at time of crop harvest from fallow sites and from root zones of fertilized field plots of tomato, soybean or corn plants cultivated in pure stand or in association with nutsedge, a competitve weed. Diagnostic methods utilized were inoculated Difco NO3(-) broth and Giltay's medium (citrate-nitrate-asparagine + mineral salts), incubated with and without the exclusion of atmospheric 02, respectively. The NO3(-) broth method usually yielded both numerically larger and significantly different (5% level) MPNs for NO3(-) reducers (5 of 7 cases larger, 3 significant) and denitrifiers (6 of 7 cases larger, 3 significant) from a given soil inoculum when compared with identical enumerations performed with Giltay's medium.

77:02G-106
INFLUENCE OF PH ON THE SORPTION OF CO(2+), ZN(2+) AND CA(2+) BY A HYDROUS MANGANESE OXIDE,
Loganathan, P., Burau, R.G., and Fuerstenau, D.W.
Coconut Research Institute, Lunuwila, Sri Lanka.
Soil Science Society of America Journal, Vol. 41, No. 1, p 57-62, January-February, 1977. 7 fig, 1 tab, 15 ref.

Descriptors: Sorption, Soil chemistry, Soil investigations, Soil chemistry properties, Calcium, Cations, Adsorption, Ion exchange.

The uptake of Co2(+), Zn2(+), and Ca2(+) by delta-Mn02 at 24.0 ± 0.5 C as a function of pH and salt concentration was investigated. At pH values <5, delta-Mn02 released structural Mn to solution phase during the sorption of Co2(+) and to a lesser extent during Zn2(+) sorption. Calcium sorption did not release any Mn to solution phase. In addition, CO2(+), Zn2(+), and Ca2(+) were shown to adsorb specifically at the delta-Mn02 surface by exchange with bound H. The pH values had very little influence on the sorption of these cations.

77:02G-107
ON THE CHEMICAL FOUNDATION OF THE SODIUM ADSORPTION RATIO,
Sposito, G., and Mattigod, S.V.
California University, Department of Soil and Environmental Sciences, Riverside, California 92521.
Soil Science Society of America Journal, Vol. 41, No. 2, p 323-329, March-April, 1977. 1 fig, 2 tab, 48 ref, 19 equ.

Descriptors: Sodium, Cation exchange, Calcium, Magnesium, Cations, Soil chemistry, Soil investigations, Soil properties, Computer programs, Soil tests.

The theoretical chemical basis of the sodium adsorption ratio (SAR) was examined in order to clarify two important issues that arise in connection with the problem of estimating potential sodium hazard: (i) the relation between SAR and the theory of cation exchange, and (ii) the implications of the universal practice of replacing SAR by what may be termed the practical SAR, which employs total concentrations of Na, Ca, and Mg instead of their free cationic concentrations. In regard to (i), it was confirmed that SAR can be given a chemical basis in terms of the Gapon cation exchange equilibrium constant which is provided in this paper with a rigorous derivation for the first time. The Gapon constant is shown to differ from the Vanselow exchange constant only because of the (arbitrary) convention adopted as to what entity is termed the ligand in the cation exchange reaction. In regard to (ii), it was shown through a direct calculation of SAR and the practical SAR for 161 different soil solutions or water extracts, utilizing a comprehensive chemical equilibrium computer program, that an exact functional relationship between the two parameters does not exist.

77:02G-108
EXCHANGE CAPACITY OF CALCIUM AND SODIUM SOILS AS DETERMINED BY DIFFERENT REPLACING CATIONS,
Ravina, I., and Gurovich, E.
Technion-Israel Institute of Technology, Faculty of Agricultural Engineering, Haifa, Israel.
Soil Science Society of America Journal, Vol. 41, No. 2, p 319-322, March-April, 1977. 2 fig, 5 tab, 26 ref.

Descriptors: Cation exchange, Calcium, Sodium, Soils, Soil investigations, Cations, Soil properties.

Experimentally determined CEC values are dependent on the nature of the initially adsorbed cation and the replacing one. Cation exchange capacities of Na-saturated and Ca-saturated soils were determined using monovalent and divalent cations. In the exchange of initially adsorbed Na or Ca by monovalent cations, the magnitude of CEC increases with increasing ionic radius or polarizability of the replacing cation. The Na soil shows a greater CEC than the Ca soils. The Na soil and Ca soil behave differently with respect to the exchange by divalent cations. While the CEC of a soil initially saturated with Ca increases as the ionic radius of the replacing cation is larger, the magnitude of CEC of a Na soil decreases.

77:02G-109
PHOSPHORUS SORPTION CHARACTERISTICS OF FLOODED SOILS,
Khalid, R.A., Patrick, W.H., Jr., and DeLuane, R.D.
Louisiana State University, Center for Wetland Resources, Baton Rouge, Louisiana.
Soil Science Society of America Journal, Vol. 41, No. 2, p 305-310, March-April, 1977. 4 fig, 3 tab, 29 ref.

Descriptors: Phosphorus, Soils, Soil investigations, Soil properties, Rice, Crop production, Louisiana.

Surface soils representing Alfisols and Inceptisols were collected from various parts of Louisiana under rice cultivation and incubated under oxidized (aerobic) and reduced (anaerobic) conditions for 2 weeks in a soil to 0.01M $CaCl2$ solution ratio of 1:5. The release of native soil P and the sorption of added inorganic P was investigated under these conditions. The soils selected for study were characterized for clay content, total carbon, extractable P, pH, and oxalate-extractable Fe, and soil properties associated with P sorption. The results show that generally more soil P was released under reduced than oxidized conditions, and this increase in soluble P under reduced conditions was significantly related to Bray no. 2 extractable P, clay content, and oxalate Fe.

77:02G-110
MEASUREMENT OF ISOTOPIC EXCHANGEABLE SOIL PHOSPHORUS AND INTERRELATIONSHIP AMONG PARAMETERS OF QUANTITY, INTENSITY, AND CAPACITY FACTORS,
Dalal, R.C., and Hallsworth, E.G.
New England University, Department of Agronomy and Soil Science, Armidale, New South Wales 2351, Australia.
Soil Science Society of America Journal, Vol. 41, No. 1, p 81-86, January-February, 1977. 6 tab, 28 ref, 10 equ.

Descriptors: Phosphorus, Soils, Soil investigations, Soil chemistry, Soil texture, Soil chemical properties.

The applicability of various techniques to measure isotopically exchangeable phosphorus for widely different soils was investigated. The E-values obtained in the laboratory by carrier-free (E-value) and carrier-methods (Ec value) were comparable to L-values obtained in the greenhouse in low-phosphorus fixing soils but were very much higher in high phosphorus fixing soils. In the latter group E-values obtained by inverse-dilution technique (E.I.D. value) were more comparable to L-values.

77:02G-111
FITTING SOLUTE BREAKTHROUGH EQUATIONS TO DATA USING TWO ADJUSTABLE PARAMETERS,
Elprince, A.M., and Day, P.R.
King Faisal University, Department of Soils and Agricultural Engineering, Al-Hassa, Saudi Arabia.
Soil Science Society of America Journal, Vol. 41, No. 1, p 39-41, January-February, 1977. 2 fig, 1 tab, 20 ref.

Descriptors: Adsorption, Anions, Soils, Soil investigations, Hydrodynamics, Soil chemistry, Soil chemical properties.

Negative adsorption of anions reduces the volume of liquid available for the transport of electrolytes in the soil, and hence affects the nature of the breakthrough curve. A similar problem arises when there are appreciable volumes of soil solution which are essentially stagnant, and thus do not contribute significantly to the convective flux. These effects can be taken into account by introducing a second adjustable parameter (the effective solution volume) into the transport equation, in addition to the dispersion coefficient. The calculations demonstrate in a given example that a least squares procedure, applied simultaneously to the two parameters during the curve-fitting process, resolves the apparent discrepancy between the theoretical breakthrough curve and the experimental data.

77:02G-112
THERMODYNAMIC STABILITY AND SOLUBILITY OF MOLYBDENUM MINERALS IN SOILS,
Vlek, P.L.G., and Lindsay, W.L.
International Fertilizer Development Center, Florence, Alabama 35630.
Soil Science Society of America Journal, Vol. 41, No. 1, p 42-46, January-February, 1977. 4 fig, 3 tab, 30 ref.

Descriptors: Molybdenum, Thermodynamics, Soil chemistry, Soil chemical properties, Soils, Soil investigations, Laboratory tests.

The chemical reactions of molybdenum in soils were studied in the laboratory. Solubility diagrams were constructed from thermodynamic data obtained from the literature and from measurements made on pure minerals. Included in these diagrams were solubility relationships for molybdenite, ilsemannite, ferrimolybdite, powellite, and wulfenite. From these diagrams it appears that wulfenite is one of the most stable Mo minerals likely to form in soils. Lack of thermodynamic data on other Mo minerals prevents their evaluation as possible reaction products. The solubility of Mo in selected Colorado soils in the pH range of 5.5 to 7.7 was plotted on the wulfenite solubility diagram. Of the 13 soils used in this study, only one showed equilibrium with respect to wulfenite. When wulfenite was added to several other soils, the molybdenum solubility increased 10 to 100 fold, confirming that wulfenite was not initially present. These wulfenite-amended soils showed a close correspondence between soluble Mo and the wulfenite solubility isotherm. In the absence of solid phase Mo compounds, the solubility of Mo in soils is controlled by specific adsorption.

77:02G-113
THE NITROGEN ISOTOPE EFFECT ASSOCIATED WITH NITRATE AND NITRITE LOSS FROM WATER-LOGGED SOILS,
Chien, S.H., Shearer, G., and Kohl, D.H.
Washington University, Center for the Biology of Natural Systems, Saint Louis, Missouri 63130.
Soil Science Society of America Journal, Vol. 41, No. 1, p 63-69, January-February, 1977. 8 fig, 3 tab, 11 ref.

Descriptors: Nitrogen, Isotopes, Nitrates, Nitrites, Saturated soils, Illinois, Glucose, Denitrification, Soils, Soil investigations.

Changes in the isotopic composition of added NO3(-), during the course of its disappearance from two central Illinois soils are reported. The only known difference in the two soils is the cultural history of the fields from which they were taken. A large (approximately threefold) difference between the two soils was observed in the isotopic fractionation factor associated with NO3(-) loss. Large differences in the two soils with respect to both the rate of NO3(-) loss and the isotopic fractionation associated with it were apparently related to differences in the two fields rather than to temporal or spatial variation within the fields. Addition of glucose (1% with respect to dry soil weight) caused the difference between the two soils to disappear. It also appreciably reduced the apparent isotopic fractionation factor in both soils.

77:02G-114
EVALUATION OF SOIL NITROGEN MINERALIZATION POTENTIALS UNDER MODIFIED FIELD CONDITIONS,
Smith, S.J., Young, L.B., and Miller, G.E.
United States Agricultural Water Quality Management Laboratory, Durant, Oklahoma 74701.
Soil Science Society of America Journal, Vol. 41, No. 1, p 74-76, January-February, 1977. 1 fig, 3 tab, 11 ref.

Descriptors: Nitrogen, Soils, Soil investigations, Mineralization, Oklahoma, Soil temperature, Soil water, Soil moisture.

Amounts of mineral N obtained by a calculation procedure and measurement in fallow plots were compared during two cropping seasons and annually with eight Oklahoma soils. The calculation procedure involved adjusting the N mineralization potentials for varying soil temperature and water content. The field N measurements involved the use of soil in plastic bags and glass filter tubes. Cropping season and annual field amounts for the eight soils, on the average, ranged from 54 to 78 ppm N. In general, the calculated amounts compared favorably to the field amounts, differences frequently being <10 ppm N. Calculated amounts correlated as well or better with the field amounts than a variety of other N availability indexes.

77:02G-115
FACTORS AFFECTING WATER DISTRIBUTION AFTER UNIFORM IRRIGATION,
Sinai, G., and Zaslavsky, D.
Technion, Department of Agricultural Engineering, Haifa, Israel.
Presented at the 1977 Winter Meeting of the American Society of Agricultural Engineers, December 13-16, 1977, Palmer House Hotel, Chicago, Illinois, p 1-29. 12 fig, 19 ref.

Descriptors: Irrigation, Irrigation water, Soil moisture, Soil water, Soil water movement, Hydraulic conductivity, Irrigation effects.

Uniformly distributed irrigation water could infiltrate laterally so that the spatial variability in moisture in the root zone would be very high. This was observed in field experiments and was proved theoretically. A suggested explanation was lateral flow in the soil due to anisotropy in its conductivity. Most cultivated layers are anisotropic so lateral flow could occur in fields.

77:02G-116
EFFECT OF DRAIN DIAMETER, OPENINGS AND ENVELOPES ON WATER TABLE DRAWDOWN,
Skaggs, R.W., and Tang, Y.K.
North Carolina State University, Department of Biological and Agricultural Engineering, Raleigh, North Carolina 27607.
Presented at the 1977 Winter Meeting of the American Society of Agricultural Engineers, December 13-16, 1977, Palmer House Hotel, Chicago, Illinois, p 1-21. 10 fig, 4 tab, 15 ref.

Descriptors: Drainage, Drainage effects, Drainage engineering, Drainage practices, Drainage systems, Soil water movement.

Numerical solutions to the Richards equation for flow to parallel drains were used to determine the effects of drain tube diameter, openings and envelopes on water table drawdown.

77:02G-117
BENEFITS OF SURFACE DRAINAGE,
Estes, R.D., and Harris, W.S.
Arkansas Cooperative Extension Service, Division of Agricultural Engineering, Little Rock, Arkansas.
Presented at the 1977 Winter Meeting of the American Society of Agricultural Engineers, December 13-16, 1977, Palmer House Hotel, Chicago, Illinois, p 1-3. 3 tab, 3 ref.

Descriptors: Drainage, Drainage effects, Economics, Surface drainage.

Land was graded in approximately 40 ha. fields with a 40 ha. field left ungraded as a check. Records of operating costs and yields were kept for a three-year period. There was no appreciable difference in operating costs or yields. The difference was in management benefits.

77:02G-118
PROCEDURES FOR EVALUATION OF DRAINAGE BENEFITS FOR AGRICULTURAL CROPS,
Manley, D.W.
United States Department of Agriculture, Soil Conservation Service, Midwest Technical Service Center, Lincoln, Nebraska.
Presented at the 1977 Winter Meeting of the American Society of Agricultural Engineers, December 13-16, 1977, Palmer House Hotel, Chicago, Illinois, p 1-6. 6 tab.

Descriptors: Economics, Drainage, Agriculture, Crop production, Drainage practices, Drainage systems.

The basic concepts and procedures used by the Soil Conservation Service for making an economic analysis of drainage for agricultural crops is described.

77:02G-119
RELATIONSHIPS BETWEEN SOIL UREASE ACTIVITY AND OTHER SOIL PROPERTIES,
Zantua, M.I., Dumenil, L.C., and Bremner, J.M.
Iowa State University, Department of Agronomy, Ames, Iowa 50011.
Soil Science Society of America Journal, Vol. 41, No. 2, p 350-352, March-April, 1977. 3 tab, 14 ref, 2 equ.

Descriptors: Iowa, Soils, Soil investigations, Soil properties, Cation exchange, Soil texture, Organic matter.

Surface samples of 21 diverse Iowa soils representing a wide range in pH, texture, and organic matter content were studied to determine the relationships between soil urease activity and other soil properties. Simple correlation analyses showed that urease activity was correlated very highly significantly with organic C (r=0.72 at the 0.1% level), total N (r=0.71 at the 0.1% level), and cation-exchange capacity (r=0.67 at the 0.1% level). Urease activity also was significantly correlated with clay (0.53 at the 5% level), sand (-0.47 at the 5% level), and surface area (0.45 at the 5% level), but was not significantly correlated with pH, silt, or $CaCO_3$ equivalent. Multiple regression analyses showed that organic matter content accounted for most of the variation in urease activity.

77:02G-120
PROFILE ACCUMULATION OF FERTILIZER-DERIVED NITRATE AND TOTAL NITROGEN RECOVERY IN TWO LONG-TERM NITROGEN-RATE EXPERIMENTS WITH CORN,
Jolley, V.D., and Pierre, W.H.
Agricultural Home Economics Experiment Station, Ames, Iowa 50011.
Soil Science Society of America Journal, Vol. 41, No. 2, p 373-378, March-April, 1977. 1 fig, 5 tab, 26 ref.

Descriptors: Fertilizers, Fertilization, Nitrates, Nitrogen, Corn, Crop response, Soils, Soil investigations, Soil profiles, Denitrification.

Two long-term N-rate experiments with corn which had been conducted in northwestern Iowa on the Moody and Galva silty clay loam soils for 17 and 15 years, respectively, were studied to determine the recovery of applied N (i) as NO3(-)N at various soil depths, (ii) as organic or fixed N, and (iii) as N removed in the harvested corn grain. The annual N rates applied as NH4NO3 were 0, 56, 112, and 168 kg N/ha on the Moody soil and 0, 90, and 134 kg N/ha on the Galva soil. Nitrogen recovery in the fertilized plots was determined by subtracting the amounts for the unfertilized treatment from those for the fertilized treatments.

77:02G-121
ION EXCHANGE REACTIONS IN NONDRIED CHAMBERS MONTMORILLONITE HYDROXY-ALUMINUM COMPLEXES,
Keren, R., Gast, R.G., and Barnhisel, R.I.
Minnesota University, Department of Soil Science, Saint Paul, Minnesota 55108.
Soil Science Society of America Journal, Vol. 41, No. 1, p 34-39, January-February, 1977. 1 fig, 3 tab, 30 ref.

Descriptors: Soils, Soil chemistry, Soil properties, Soil investigations, Montmorillonite, Clays, Sodium, Adsorption, Cation exchange.

The extent and mechanisms by which hydroxy-Al interlayers may reduce the CEC of Chambers montmorillonite were studied using 22-Na labeled clay. Clay-hydroxy-Al complexes were formed by added AlCl3 and NaOH at pH 7, 5-9, 5. AlCl3 was added at 4, 8, or 16 meq/g clay and either before, after, or simultaneously with NaOH. Addition of 16 meq AlCl3/g clay followed by NaOH resulted in CEC reductions of 60, 40, and 10% at pH 7.5, 8.5, and 9.5 as measured by Na adsorption. However, there was no trapped or nonexchangeable 22-Na observed in any of the systems. Since the charge on the hydroxy-Al is negligible at these pH's, the CEC reduction is apparently due to trapped Al.

77:02G-122
DRAINAGE LAW ASSISTS LAND DRAINAGE,
Irwin, R.W., and Johnston, J.R.
Guelph University, Department of Engineering, Guelph, Ontario, Canada.
American Society of Agricultural Engineers, Post Office Box 410, Saint Joseph, Michigan 49085, Paper Number 77-2560. 59 fig.

Descriptors: Laws, Drainage, Drainage systems, Drains, Drainage practices.

Drainage law in Ontario is integrated to provide systems of procedures, financing and inspections to ensure that agricultural drainage proceeds in a deliberate and fair way. The law covers the construction of outlet drains, on-farm tile drains and the regulation of the drainage construction industry.

77:02G-123
MODELING INFILTRATION UNDER MOVING SPRINKLER IRRIGATION SYSTEMS,
Slack, D.C.
Minnesota University, Department of Agricultural Engineering, Saint Paul, Minnesota.
Presented at the 1977 Winter Meeting of the American Society of Agricultural Engineers, December 13-16, 1977, Palmer House Hotel, Chicago, Illinois, p 1-23.
9 fig, 1 tab, 21 ref, 10 equ.

Descriptors: Model studies, Infiltration, Sprinkler irrigation, Irrigation, Irrigation systems, Soils, Simulation analysis.

A modified Mein and Larson model was employed to predict time to surface ponding under two types of center pivot irrigation systems on two agricultural soils. Results were compared with those observed in the field. The model did a good job of predicting time to surface ponding but did not perform as well as for predicting volume infiltrated at ponding.

77:02G-124
NONLINEAR ADSORPTION IN LAYERED POROUS MEDIA FLOW,
Lin, S.H.
Polytechnic Institute of New York, Department of Chemical Engineering, Brooklyn, New York.
Journal of the Hydraulics Division, American Society of Civil Engineers, Vol. 103, No. HY9, Proceedings Paper 13192, p 951-958, September 1977. 3 fig, 11 ref, 2 append.

Descriptors: *Adsorption, *Dispersion, *Porous media, *Model studies, Mathematical models, Seepage, Seepage control, Equations, Soil water, Soil water movement, Solutes, Groundwater.

Dispersion and adsorption of solute in multilayer saturated porous media with constant specific discharge were examined. Differential equations were formulated for describing the solute concentration in two-layer porous media. A general nonlinear equilibrium adsorption isotherm of the Freundlich type was considered. The nonlinear coupled differential equations were solved by the orthogonal collocation method to give the solute concentration distributions in the media when subject to a step-change or an exponential input. It was found that under many circumstances, the general dispersion model can be reduced to a simpler plug-flow model by neglecting the dispersion component in the governing differential equations. A criterion for this simplification also was suggested.

77:02G-125
TRANSIENT DRAINAGE EQUATIONS FOR NONHOMOGENEOUS SOILS,
Chu, S.T.
South Dakota State University, Department of Agricultural Engineering, Brookings, South Dakota.
Transactions of the American Society of Agricultural Engineers, Vol. 20, No. 6, p 1085-1088, November-December, 1977. 3 fig, 3 tab, 9 ref.

Descriptors: *Drainage, *Soils, *Unsteady flow, *South Dakota, Water table, Theoretical analysis, Model studies, Mathematical models, Analytical techniques, On-site tests, Water levels, Hydraulic conductivity, Equations, Soil physical properties, Nonhomogeneous soils, Drain spacing.

One of the limitations inherent in the derivation of many transient drainage equations is the assumption of a homogeneous soil. Graphical representation of transient drainage equation for nonhomogeneous soil was obtained by a scheme devised by Bouwer. He devised a scheme where the soil profile is split up into a number of layers. Within each layer, the soil parameters were considered as constants. He combined the solutions for each layer and obtained the solution of the Green and Ampt infiltration equation for nonhomogeneous soils. The application of the theoretical solution to predict the fall of a water table was illustraed. An evaluation of the theory by field measurements was presented. Good agreement between the theoretical and field measured water table height was found.

77:02G-126
VERTICAL DRAINAGE IN FIELD CORES,
Wells, L.G., and Skaggs, R.W.
Kentucky University, Department of Agricultural Engineering, Lexington, Kentucky.
Transactions of the American Society of Agricultural Engineers, Vol. 20, No. 1, p 79-84, January-February, 1977. 7 fig, 2 tab, 15 ref.

Descriptors: *Drainage, *Cores, *Laboratory tests, Soil water movement, Soil tests, Mathematical models, Hydraulic conductivity, Soil types, Pressure head, Water table, Irrigation.

In this study, one-dimensional water movement during drainage was examined experimentally using large field cores. The cores were 51 cm in diameter and were considered large enough to incorporate heterogenities such as worm holes and plant roots, yet small enough to bring into the lab where experimental measurements could be made under controlled conditions. The objective of the study was to evaluate alternate methods of characterizing one-dimensional drainage in natural soils with relatively shallow water tables.

77:02G-127
OPTIMAL PREDICTION OF PONDING,
Smith, R.E., and Parlange, J.Y.
Agricultural Research Service, Fort Collins, Colorado.
Transactions of the American Society of Agricultural Engineers, Vol. 20, No. 3, p 493-496, May-June, 1977. 1 tab, 6 ref, 1 append.

Descriptors: *Ponding, *Runoff, *Rainfall, *Model studies, Mathematical models, Soil physics, Porous media, Infiltration, Precipitation (atmospheric), Hydraulic conductivity, Moisture content, Saturated soils, Surface runoff, Soil science, Watersheds (basins).

Soil physics and porous media flow are being used more and more today to develop means to predict hydrologic response of watersneds and to provide better management tools for water resources. One important variable in studying watershed response to storm rainfall is the time between initiation of rainfall and the iniation of surface runoff, or ponding time. This study described a mathematical technique that allows improved estimates of the delay in watershed response to rain, knowing only two basic soil parameters from the physics of soil water flow.

77:02G-128
SOIL WATER MODELING II: ON SENSITIVITY TO FINITE DIFFERENCE GRID SPACING,
Amerman, C.R., and Monke, E.J.
Agricultural Research Service, Columbia, Missouri.
Transactions of the American Society of Agricultural Engineers, Vol. 20, No. 3, p 478-484, 488, May-June, 1977. 10 fig, 2 tab, 18 ref.

Descriptors: *Soil water, *Soil water movement, *Model studies, *Mathematical models, Infiltration, Finite element analysis, Analytical techniques, Mathematics, Water levels, Flow, Hydraulic conductivity, Saturated flow, Unsaturated flow, Hydrology.

The influence of finite difference grid size on soil water flow model accuracy was studied using two cases. One case was of steady, two-dimensional infiltration using the successive overrelaxation (SOR) method of solving finite difference equations. The other case was of transient, two-dimensional infiltration using the alternating direction implicit (ADI) method. Finite difference expressions were formulated for both cases using central differencing techniques. In the transient case, a very small grid size in both time and space dimensions was necessary at the initiation of infiltration. Furthermore, the ADI method for the nonlinear case was only conditionally stable at least at the initiation of infiltration. As infiltration proceeded, however, both the time and the space grid sizes could be made larger. Indicators of a grid size that was obviously too coarse were a fluctuating infiltration rate in the transient case and irregulary shaped equipotential lines in the steady-state case. Although the models were nonlinear, they both converged; for example, successively smaller grid sizes yielded solutions that asymptotically approached a limit. For a given regular grid size, considerable computational saving could be effected without appreciable loss of accuracy by using an irregular grid in which the regular grid size was duplicated in the part of the section exhibiting the greatest curvature of equipotential lines, while larger grid sizes could be used in other parts of the section. Smaller grid sizes also were needed in regions where hydraulic gradient changed rapidly. Accuracy of estimation varied approximately with the inverse of grid size rather than with the square of the inverse, as is generally claimed for central differencing on a square grid.

77:02G-129
A CONTINUOUS WATER BUDGET MODEL FOR WESTERN KANSAS,
Neibling, W.H., Koelliker, J.K., and Ohmes, F.E.
United States Department of Agriculture, Agricultural Research Service, Agricultural Engineering Building, Purdue University, West Lafayette, Indiana.
Presented at the 1977 Annual Meeting of the American Society of Agricultural Engineers, June 26-29, 1977, Raleigh, North Carolina, North Carolina State University, p 1-17. 5 fig, 3 tab, 22 ref, 4 equ.

Descriptors: Kansas, Model studies, Evapotranspiration, Soil moisture, Soil water, Soil profiles, Climate.

A continuous water-budget model was developed and calibrated for use in western Kansas. Daily potential evapotranspiration (PET), actual ET, and soil moisture changes in a 213 cm soil profile were calculated from inputs of crop and soil moisture characteristics and daily meteorological observations.

77:02G-130

ADSORPTION OF ALUMINUM BY A SMECTITE: I. SURFACE HYDROLYSIS DURING CA2(+)(-) AL3(+) EXCHANGE,

Bloom, P.R., McBride, M.B., and Chadbourne, B.
Cornell University, Department of Agronomy, Ithaca, New York 14853.
Soil Science Society of America Journal, Vol. 41, No. 6, p 1068-1072, November-December, 1977. 1 fig, 6 tab, 16 ref, 5 equ.

Descriptors: Adsorption, Aluminum, Montmorillonite, Clays, Soils, Soil chemistry, Soil properties.

The exchange of Ca by Al in montmorillonite suspensions adjusted to low pH (approximately equal to 4) was investigated by measurement of Ca, Al, and pH in the solution phase before and after the addition of clay. Adsorption of Al was accompanied by a release of protons to solution, indicating that the clay surfaces promoted hydrolysis of Al3+ when only partial coverage of exchange sites by Al had occurred. Calculations showed a two- to nine fold increase in the degree of hydrolysis at the surface relative to the value for solution.

77:02G-131

ADSORPTION OF ALUMINUM BY A SMECTITE: II. AN AL3(+)(-)CA2(+),

McBride, M.B., and Bloom, P.R.
Cornell University, Department of Agronomy, Ithaca, New York 14853.
Soil Science Society of America Journal, Vol. 41, No. 6, p 1073-1077, November-December, 1977. 3 fig, 2 tab, 11 ref, 9 equ.

Descriptors: Model studies, Aluminum, Montmorillonite, Clays, Soils, Soil chemistry, Soil properties.

The adsorption of Al by Ca2+-montmorillonite has been found to be described by a Langmuir-type equation in which the activity of Al3+ in solution is a function of the coverage of the mineral surfaces by Al. The classical mass-action equations were inadequate in describing the exchange reaction where the Ca2+ activity was allowed to vary, weighting the effect of the Ca2+ ion activity on the equilibrium too heavily. The model suggests that the relative solution-like nature of adsorbed Ca2+ compared to the much more strongly adsorbed Al3+. Hydrolysis and precipitation reactions of Al3+ at higher pH complicated the exchange model by introducing significant quantities of adsorbed hydroxyl-Al into the system.

77:02G-132

PHOSPHATE ADSORPTION ON AN OXISOL,

Parfitt, R.L.
Soil Bureau, Division of Scientific and Industrial Research, Lower Hutt, New Zealand.
Soil Science Society of America Journal, Vol. 41, No. 6, p 1064-1067, November-December, 1977. 1 fig, 1 tab, 22 ref.

Descriptors: Adsorption, Phosphates, Soil chemistry, Soil properties.

Adsorption isotherms for phosphate on the A and B horizon of an oxisol from Papua New Guinea showed high affinity adsorption at low solution concentrations and a linear increase in adsorption at higher solution concentrations. Adsorption increased with decrease in pH in the range 3 to 8. Comparison with data obtained under similar conditions with synthetic goethite (alpha-FeOOH) and gibbsite (Al(OH)3) suggested that phosphate reacted with FeOH and FeOH2+ groups on soil iron oxide surfaces to form a binuclear bridging FeOP(O2)OFe complex and with exposed Al(OH)H2O on kaolinite edges and on hydroxy-aluminum species to form a binuclear or bidentate phosphate complex. At higher phosphate concentrations isotherms showed continued adsorption which may be due to a further reaction involving hydroxy-aluminum groups.

77:02G-133

APPLICATIONS AND MISAPPLICATIONS OF THE LANGMUIR EQUATION TO SOIL ADSORPTION PHENOMENA,

Harter, R.D., and Baker, D.E.
New Hampshire University, Institute of Natural and Environmental Resources, Durham, New Hampshire 03824.
Soil Science Society of America Journal, Vol. 41, No. 6, p 1077-1080, November-December, 1977. 2 fig, 2 tab, 12 ref, 10 equ.

Descriptors: Adsorption, Soils, Soil investigations, Soil properties, Soil chemistry.

When the development of the Langmuir adsorption equation is critically examined, it is evident that the equation soil scientists have been using ($C/x/m = C/k + 1/kb$, where C is concentration of adsorbate, x/m is the amount adsorbed per unit weight adsorbent, k is the adsorption maximum, and b is a constant) is in the wrong form. This error is of no great importance when the equation is merely used to obtain a calculated adsorption maximum for comparison to other adsorbent properties. However, it does become important when attempts are made to understand adsorption dynamics and bonding strengths. The commonly reported curvilinear nature of the C/x/m vs. C plots is simply the result of not considering the effect of desorbed ions in the equilibrium solution, rather than being due to multiple adsorption mechanisms. When the equation is corrected by considering desorbed ions, the isotherm becomes linear. In addition, the constant, b, of the Langmuir equation is not simply related to the bonding energy of the adsorbed ion, but to the ratio of adsorbed and desorbed ion bonding energies.

77:02G-134

AMMONIA VOLATILIZATION FROM SOILS: EQUILIBRIUM CONSIDERATIONS,

Avnimelech, Y., and Laher, M.
Israel Institute of Technology, Department of Agricultural Engineering, Technion City, Haifa, Israel.
Soil Science Society of America Journal, Vol. 41, No. 6, p 1080-1084, November-December, 1977. 2 fig, 1 tab, 9 ref, 18 equ.

Descriptors: Ammonium, Soils, Soil chemistry, Soil properties, Fertilizers, Nutrients.

The volatilization of ammonia from soils as a function of the system's properties is analyzed theoretically and experimentally. The final concentration of ammonium held by the soil increases with an increase in hydrogen ion activity, with the initial ammonium concentration, and with partial pressure of ammonia in the air. An increase in the buffer capacity of the soil leads to a decrease in the final ammonium concentration. A good agreement has been found between measured and computed values for NH_3 and NH_4 concentrations during the process. The pH of the soil is the dominant factor controlling the extent of ammonia volatilization only when the soil's buffer capacity is high, or, when the concentration of ammonium in the soil is low. At high pH and high initial ammonium concentrations, the dominant factor controlling the reaction is the buffer capacity of the soil.

77:02G-135

ORGANIC PHOSPHATE TRANSPORT AND HYDROLYSIS IN SOIL: THEORETICAL AND EXPERIMENTAL EVALUATION,

Castro, C.L., and Rolston, D.E.
California University, Department of Land, Air, and Water Resources, Davis, California 95616.
Soil Science Society of America Journal, Vol. 41, No. 6, p 1085-1091, November-December, 1977. 7 fig, 1 tab, 28 ref, 7 equ.

Descriptors: Phosphates, Soils, Soil chemistry, Fertilizers, Irrigation, Irrigation water.

An understanding of the movement, hydrolysis, and retention of organic phosphates in soils is necessary to evaluate possible advantages of the compounds as fertilizers, based upon their characteristic of increased vertical movement over that of inorganic phosphates when applied with irrigation water. Pulses of chloride and glycerophosphate were applied to 4-, 10-, and 20-cm long Panoche clay loam soil columns maintained slightly water-unsaturated. The concentration of glycerophosphate in the pulse applications varied from 386 to 1,110 ppm P. An analytical solution assuming first order kinetics and a reversible, linear isotherm for glycerophosphate hydrolysis and sorption, respectively, was compared with measured glycerophosphate concentrations in the column effluent. An analytical solution of the coupled equations for simultaneous transport of organic phosphate and orthophosphate assuming a linear, reversible isotherm for orthophosphate adsorption is given.

77:02G-136
TRAFFIC COMPACTION AND IRRIGATION,
Trouse, A.C., Jr.
United States Department of Agriculture, Agricultural Research Service, National Tillage Machinery Laboratory, Auburn Alabama.
Proceedings of the 1977 Annual Technical Conference, Irrigation For All Reasons, p 50-53, February 13, 15, 1977. 1 tab.

Descriptors: Irrigation, Irrigation practices, Irrigation effects, Soils, Soil compaction, Soil moisture, Soil water, Crop production.

When traffic compaction is present, no amount of irrigation will guarantee superior crop yields. Neither will well irrigated fields guarantee top production when soils are only mildly compressed, a common, but less organized, situation on many farms today. If moisture is to increase crop production, it must be both available and readily retrievable when needed, by whatever its method of entry into the soil.

77:02G-137
FINITE ELEMENT MODELING OF UNSATURATED FLOW,
Bloomsburg, G.L., and Bloomfield, R.A.
Idaho University, Department of Agricultural Engineering, Moscow, Idaho.
Presented at the 1977 Winter Meeting of the American Society of Agricultural Engineers, December 13-16, 1977, Palmer House Hotel, Chicago, Illinois, p 1-21, 7 fig, 3 tab, 5 ref.

Descriptors: Simulation analysis, Unsaturated flow, Mining, Infiltration, Rainfall, Evaporation, Model studies, Soil water movement, Soil water.

This report concerns the use of a finite element computer program to simulate unsaturated flow through retorted oil shale piles under various conditions of ponding, infiltration due to rainfall, and evaporation. Field data from seepage ponds constructed in waste shale near Rifle, Colorado, are compared with data from computer simulation.

77:02G-138
APPLICATION OF AN INFILTROMETER SYSTEM FOR DESCRIBING INFILTRATION INTO SOILS,
Brakensiek, D.L., Rawls, W.J., and Hamon, W.R.
United States Department of Agriculture, Agricultural Research Service, Boise, Idaho.
Presented at the 1977 Winter Meeting of the American Society of Agricultural Engineers, December 13-16, 1977, Palmer House Hotel, Chicago, Illinois, p 1-14, 7 fig, 4 tab, 24 ref, 3 equ.

Descriptors: Infiltration, Soil water, Soil water movement, Model studies, Equations.

The design and operation of an infiltrometer system is discussed. The analysis of the infiltrometer data is illustrated by estimation of the parameters in the Green and Ampt infiltration equation. The Green and Ampt equation seems to model the observed point infiltration process very well. Future needs in infiltrometer studies are presented.

77:02G-139
INFILTRATION EQUATION: DERIVATION TO INCLUDE SURFACE EFFECTS
Gregory, J.M., Johnson, H.P., and Kirkham, D.
Missouri University, Department of Agricultural Engineering, Columbia, Missouri.
Presented at the 1977 Winter Meeting of the American Society of Agricultural Engineers, December 13-16, 1977, Palmer House Hotel, Chicago, Illinois, p 1-31, 4 fig, 2 tab, 15 ref, 76 equ.

Descriptors: Infiltration, Equations, Model studies, Soil water, Soil water movement.

An infiltration equation capable of modeling changing surface conditions has been derived by use of the energy equation. This equation has the surface effects grouped in one function which can be separated from other variables affecting infiltration. When the surface term is set equal to zero, the equation reduces to the same form as the Green-Ampt equation.

77:02G-140
WATER MOVEMENT AND INFILTRATION IN A FROZEN SOIL: THEORETICAL AND EXPERIMENTAL CONSIDERATIONS,
Steenhuis, T.S., Bubenzer, G.D., and Walter, M.F.
Cornell University, Department of Agricultural Engineering, Ithaca, New York 14853.
Presented at the 1977 Winter Meeting of the American Society of Agricultural Engineers, December 13-16, 1977, Palmer House Hotel, Chicago, Illinois, p 1-31. 8 fig, 2 tab, 20 ref, 13 equ. 2 append.

Descriptors: Soil water, Soil water movement, Infiltration, Soils, Soil properties, Temperature, Soil temperature.

Water movement in a frozen soil was compared theoretically and experimentally with a nonfrozen soil. During the winter, water movement was upwards to the surface. Infiltration of water was only possible when the soil temperature was at freezing point, but not below, or when the soil contained macropores.

77:02G-141
CAPILLARY POTENTIAL DISTRIBUTIONS IN ROOT ZONES USING SUBSURFACE IRRIGATION,
Thomas, A.W., Duke, H.R., and Kruse, E.G.
United States Department of Agriculture, Watkinsville, Georgia.
Transactions of the American Society of Agricultural Engineers, Special Edition, Vol. 20SW, p 62-67, February 20, 1977. 11 fig, 8 ref.

Descriptors: Infiltration, Root zones, Subsurface irrigation, Corn, Irrigation systems, Soils, Irrigation design, Capillary water.

An experimental study was conducted to study infiltration from buried sources which represented field irrigation laterals. Capillary potentials in the root zone of barley and corn were measured during the growing season and compared with measured and calculated steady-state values. Design evaluation of subsurface irrigation system was introduced and example calculations were presented.

77:02G-142
THE SOIL MOISTURE COMPONENT OF MATHEMATICAL CATCHMENT SIMULATION MODELS,
Manley, R.E.
Seven-Trent Water Authority, Birmingham (England).
Journal of Hydrology, Vol. 35, No. 3/4, p 341-356, November 1977. 5 fig, 4 tab, 19 ref.

Descriptors: *Watersheds (basins), *Runoff, *Model studies, Flow, Mathematical models, Soil moisture, Infiltration, Permeability, Overland flow, Precipitation (atmospheric), Rainfall, Soil water movement, Percolation, Evapotranspiration, Groundwater, Channel flow, Hydrology.

The role of soil moisture in mathematical catchment simulation models was discussed, and requirements for this component of the model were suggested. A model was described which embodies the suggested characteristics, particular emphasis being placed on its soil moisture component. The results from the application of this model were presented.

77:02G-143
NONLINEAR ADSORPTION IN POROUS MEDIA WITH VARIABLE POROSITY,
Lin, S.H.
Melbourne University, Department of Chemical Engineering, Parkville (Australia).
Journal of Hydrology, Vol. 35, No. 3/4, p 235-243, November 1977. 6 fig, 17 ref.

Descriptors: *Porous media, *Adsorption, *Dispersion, *Model studies, *Porosity, Mathematical models, Solutes, Seepage, Soil water, Soil water movement, Nutrients, Nutrient removal, Nitrogen, Phosphorus, Liquid wastes, Path of pollutants, Soil properties.

A numerical procedure was presented for predicting the solute dispersion and adsorption in heterogeneous porous media. Several porosity equations with decreasing or increasing porosity were proposed to represent the porosity variation and were used to simulate how the porosity variation affects the solute concentration distribution. The solute responses subject to a step change or an exponential change input revealed some interesting characteristics.

77:02G-144
ALFALFA PRODUCTION ON A PROFILE-MODIFIED SLOWLY PERMEABLE SOIL,
Eck, H.V., Martinez, T., and Wilson, G.C.
United States Department of Agriculture, Southwestern Great Plains Research Center,
Bushland, Texas 79012.
Soil Science Society of America Journal, Vol. 41, No. 6, p 1181-1186, November-December, 1977. 2 fig, 6 tab, 8 ref.

Descriptors: Irrigation, Irrigation effects, Alfalfa, Crop production, Crop response, Soils, Soil investigations.

Yields of irrigated alfalfa are lower on Pullman clay loam than on more permeable soils in the same climatic area. The objectives of this study were to determine (i) the residual effect of thoroughly mixing the soil profile on alfalfa growth and production, and (ii) the amounts and timing of irrigations required for maximum alfalfa production on modified and unmodified soil profiles.

77:02G-145
POTASSIUM ACCUMULATION AND MOVEMENT IN AN IRRIGATED SOIL TREATED WITH ANIMAL MANURES,
Pratt, P.F., and Laag, A.E.
California University, Department of Soil and Environmental Science, Riverside, California.
Soil Science Society of America Journal, Vol. 41, No. 6, p 1130-1132, November-December, 1977. 3 fig, 3 tab, 9 ref.

Descriptors: Salinity, Potassium, Irrigation effects, Soils, Soil investigations, Animal wastes, Soil chemistry.

Data from a 4-year experiment with animal manures are reported. Soluble and exchangeable K and K/Cl ratios indicated that K moved into the 90- to 120-cm depth, but little if any moved below the 120-cm depth. Potassium/Cl ratios indicated that K moved down in a relatively abrupt front, that the 0- to 30-cm and 30- to 60-cm depths had nearly equilibrated with the K input, but that deeper layers had not. Soluble K accumulated in the soil in proportion to the amount of manure added and reached a maximum of 36.5% of the total soluble cations in the saturation extract of the surface layer of the plots that received the highest rate of manure. The maximum exchangeable K was found in the 30- to 60-cm depth of the same plots. The K fixed in the soil appeared to be greater than the reduction in CEC.

77:02G-146

DISTRIBUTION PATTERN OF INORGANIC NITROGEN FOLLOWING ANHYDROUS AMMONIA INJECTION INTO A VERTISOL,

Khengre, S.T., and Savant, N.K.
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Soil Science Society of America Journal, Vol. 41, No. 6, p 1139-1141, November-December, 1977. 3 fig, 1 tab, 20 ref.

Descriptors: Nitrogen, Ammonia, Soils, Soil investigations, Soil chemistry, Soil moisture, Soil water.

Distribution patterns of inorganic forms of N and diffusion coefficients of NH4+ were studied after injection of 800 mg of anhydrous NH3-N per dish, each dish containing 1 kg of soil (density 1.20 g/cu cm) maintained at 1/3-bar moisture percentage and incubated for 120 days. Bell-shaped distribution patterns of NH4+ and undissociated NH3 (aq) were observed. Diffusion coefficients of NH4+ decreased with incubation time.

77:02G-147

NITROGEN FERTILIZATION: II. EFFECT ON THE SOIL SOLUTION COMPOSITION, ACIDITY, AND NITRATE ADSORPTION.

Lutz, J.A., Jr., Kroontje, W., and Hahne, H.C.H.
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Soil Science Society of America Journal, Vol. 41, No. 3, p 568-572, May-June, 1977. 3 tab, 31 ref.

Descriptors: Nitrogen, Nutrients, Fertilizers, Fertilization, Nitrates, Adsorption, Soils, Soil investigations, Clays, Irrigation, Irrigation effects.

Analyses were performed on soil solution extracts of samples obtained from depths where nitrate accumulation occurred due to ammonium nitrate applications on three different soils, for example, Cecil fine sandy loam, Groseclose silt loam, and Davidson clay loam. Comparisons were made between treatments of moderate and high N applications in all three soils and between irrigated and nonirrigated conditions on the Cecil and Davidson soils.

77:02G-148

NUMERICAL EVALUATION OF GRANULE SIZE EFFECT ON DISSOLUTION RATE OF POTASSIUM SILICATES AND POTASSIUM POLYPHOSPHATE IN AQUEOUS SOLUTION,

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National Institute of Agricultural Sciences, 2-1-7 Nishigahara, Kita-ku, Tokyo, 114 Japan.
Soil Science Society of America Journal, Vol. 41, No. 3, p 637-640, May-June, 1977. 2 fig, 3 tab, 12 ref, 4 equ.

Descriptors: Potassium, Kinetics, Soils, Soil investigations, Soil properties, Soil chemistry, Soil water, Soil moisture.

The rate of potassium dissolution from spherical granules of K20·4Si02, K20·5Si02, and (Kp03)n was measured in water, NH4Cl and acetic acid solutions. Experimental results were analyzed using first order kinetics, involving a rate constant (k) and the concentration at saturation (cs). The kCs values in H20 were 3.65 x 10-2, 1.17 x 10-2, and 7.08 x 10-3 mg K/mm2 per day for K20·4Si02, K20·5Si0s, and (KP03)n, respectively. Extremely high kCs values were obtained for the dissolution of (KP03)n in solvents rich in H+ or NH4+. Based on these experimental data and assumed values for Cs, the whole process of K dissolution from each mineral at various granule sizes in aqueous solutions was calculated by the equations given by Hixson and Crowell (1931).

77:02G-149
AN ALKALINE OXIDATION METHOD FOR DETERMINATION OF TOTAL PHOSPHORUS IN SOILS,
Dick, W.A., and Tabatabai, M.A.
Iowa State University, Department of Agronomy, Ames, Iowa 50011.
Soil Science Society of America Journal, Vol. 41, No. 3, p 511-514, May-June, 1977. 7 tab, 13 ref.

Descriptors: Phosphorus, Soils, Soil investigations, Nutrients, Fertilizers, Fertilization, Sediments.

A simple and precise method for determination of total phosphorus in soils and lake sediments is described. A mixture of soil and sodium hypobromite solution is boiled to dryness in a sand bath (260-280 C), and the total amount of orthophosphate is extracted with 1N H2SO4 and determined colorimetrically by the molybdenum blue method. Analysis of a group of diverse soil, lake sediment, and sewage sludge samples indicated that the proposed method and the HClO4 digestion method gave essentially the same total P values. With 10 soils, the average results by the proposed NaOBr oxidation method were 1% higher than those obtained by the HClO4 digestion method and 4% lower than those obtained by the Na2CO3 fusion method. A comparison of methods used for colorimetric determination of the orthophosphate extracted indicated that the results by the recently developed method by Dick and Tabatabai agree closely with those obtained by the method of Murphy and Riley. Digestion of samples with sodium hypobromite solution and colorimetric determination of the extracted P by the method of Murphy and Riley permits rapid analysis of a large number of samples at one time.

77:02G-150
SHORT-TERM REPLENISHMENT OF SOIL SOLUTION PHOSPHORUS,
Peaslee, D.E., and Ballaux, J.C.
Kentucky Agricultural Experiment Station, Lexington, Kentucky 40506.
Soil Science Society of America Journal, Vol. 41, No. 3, p 529-531, May-June, 1977. 1 fig, 1 tab, 13 ref.

Descriptors: Phosphorus, Nutrients, Fertilization, Fertilizers, Soil properties, Crop production, Soils, Soil chemistry.

Depletion of soil solution P from zones around plant roots indicates that diffusive flux of P from the soil solution to the plant root is inadequate to keep pace with removal by plant roots. Consequently, the concentration and/or concentration gradients of solution P maintained under conditions of repeated removal over time are an important soil property that is a factor in determining the quantity of P diffusing to root surfaces. This study was conducted to determine the P release characteristics of five soils differing in P retention properties and pretreated with quantities of P equivalent to their sorption maxima.

77:02G-151
OBSERVED AND PREDICTED RATES OF PHOSPHORUS DIFFUSION IN SOILS OF VARYING BULK DENSITY AND WATER CONTENT,
Hira, G.S., and Singh, N.T.
Punjab Agricultural University, Department of Soils, Ludhiana, India.
Soil Science Society of America Journal, Vol. 41, No. 3, p 537-540, May-June, 1977. 5 fig, 2 tab, 14 ref, 6 equ.

Descriptors: Phosphorus, Soils, Soil chemistry, Soil investigations, Soil water, Soil moisture, Bulk density, Adsorption.

The self-diffusion coefficient of phosphorus (D) was measured at bulk densities of 1.25, 1.45, 1.60 and 1.75 g/cm3 and at three levels of soil water content in Choa sandy loam and Haibowal silty clay loam. The tortuosity factor was calculated from the self-diffusion coefficient of 36Cl. Appropriate values of the adsorption isotherm and the tortuosity factor were used to predict P diffusion coefficient in both soils. The tortuosity factor increased with increase in soil bulk density and increase in water content from 7 to 18% in the Choa soil and 14 to 25% in the Haibowal soil. As bulk density increased from 1.25 to 1.60 g/cm3, the observed diffusion coefficient values averaged over all water contents, increased from 0.05 x 10(-10) cm sq/sec in Choa and Haibowal soils, respectively. Further increase in bulk density to 1.75 g/cu cm decreased the diffusion coefficient of P in both soils to a greater extent than at low bulk density. The phosphate ion-soil particle interaction was minimum at a soil bulked density of 1.60 g/cu cm.

77:02G-152

AMMONIA VOLATILIZATION FROM SURFACE APPLICATIONS OF AMMONIUM COMPOUNDS TO CALCAREOUS SOILS: VI. EFFECTS OF INITIAL SOIL WATER CONTENT AND QUANTITY OF APPLIED WATER,

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Soil Science Society of America Journal, Vol. 41, No. 2, p 358-363, March-April, 1977. 5 fig, 1 tab, 12 ref.

Descriptors: Ammonia, Soils, Soil investigations, Irrigation, Irrigation effects, Soil water, Soil moisture, Soil water movement.

Ammonia losses from $(NH_4)_2SO_4$(AS) and NH_4NO_3(AN) applied to the surface of initially wet and initially dry soils, when followed by irrigation, were generally greater from the initially wet soils, especially when water application rates were <2.5 cm. The greatest NH_3 loss occurred at the lowest water addition and the least loss at the highest water addition. The addition of 20.3 cm of water to a Harkey silty clay loam did not reduce NH_3 loss below that found with the addition of 5.1 cm of water. Ammonium was moved deeper into the soil by water in the initially wet soil than into the initially dry soil.

77:02G-153

ENVIRONMENTAL IMPLICATIONS OF TRENDS IN AGRICULTURE AND SILVICULTURE. VOLUME 1: TREND IDENTIFICATION AND EVALUATION,

Unger, S.G.
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United States Department of Commerce, National Technical Information Service, PB-274 233, October 1977. 188 p, 37 fig, 32 tab, 55 ref, 1 append.

Descriptors: Agriculture, Silviculture, Environmental effects, Environmental quality management.

Current and emerging trends in United States agriculture and silviculture that will have the most significant environmental implications in both the short term (1985) and the long term (2010) are determined and assessed. Five major subsectors of agriculture and silviculture were included in the analysis: (1) nonirrigated crop production, (2) irrigated crop production, (3) feedlot production, (4) range and pasture management, (5) silviculture and harvest management. Within each subsector, numerous trends and developments were identified and defined by the Contractor. Thereafter, an evaluation workshop, comprised of subsector professionals from throughout the nation, evaluated, rated and rank-ordered the most significant environmentally related trends.

77:02G-154

SULFURIC ACID AS AN AMENDMENT FOR RECLAIMING SOILS HIGH IN BORON,

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Soil Science Society of America Journal, Vol. 41, No. 6, p 1098-1101, November-December, 1977. 1 fig, 3 tab, 29 ref.

Descriptors: Adsorption, Laboratory studies, Sulfuric acid, Boron, Leaching, Soils, Soil profiles, Soil amendments.

Laboratory results indicated that sulfuric acid can effectively aid in reclaiming soils high in boron. Results of a study, using 80-cm columns of a soil high in B, indicated that a surface application of 3.22 metric tons/ha of concentrated (96%) H_2SO_4 followed by leaching with 3 pore volumes, p.v. of water was nearly as effective in reducing the level of water-soluble soil B as was leaching with 16 p.v. of water. A direct pH effect on B adsorption affinity can explain the enhanced reclamation effect found at lower soil column depths. Data suggested that competition by silicate ion for adsorption sites may be contributing to the enhanced desorption of B at lower soil depths.

77:02G-155

STABILIZATION OF CALCIUM BY SURFACE CHARGE VARIATION IN AN OXISOL,

Munns, D.N., and Fox, R.L.
California University, Department of Soils and Plant Nutrition, Davis, California 95616.
Soil Science Society of America Journal, Vol. 41, No. 4, p 682-685, July-August, 1977. 3 fig, 24 ref.

Descriptors: Calcium, Soils, Soil investigations, Soil chemistry, Soil water, Soil moisture, Cation exchange, Salts.

In the surface layer of a Ca-deficient, fine-textured Hawaiian Oxisol, concentrations of Ca in solution were poised against tendencies to increase with liming in the pH-range 5-6, and to decrease with dilution in the range of water content 0.35 to 2.0. Effects of lime and water content on the distribution of Ca between solid phase and solution were shown to be quantitatively consistent with effects of pH and ionic strength on exchange capacity. Relationships between soil pH, cation exchange capacity, and dissolved Ca were determined in soil samples taken from a field-liming trial. Effects of ionic strength on exchange capacity were determined by summation of adsorbed metal cations after equilibration of soil samples in different salt solutions. Effects of water content on cations in solution were determined by analysis of solutions centrifugally extracted at various water contents.

77:02G-156

SHORT COMMUNICATION: EFFECT OF SOIL MOISTURE ON THE RELEASE OF ORGANIC CARBON FROM WHEAT ROOTS,

Martin, J.K.
Commonwealth Scientific and Industrial Research Organization, Division of Soils, Glen Osmond, South Australia 5064.
Soil Biology and Biochemistry, Vol. 9, No. 4, p 303-304, 1977. 1 tab, 6 ref.

Descriptors: Soil water, Soil moisture, Carbon, Wheat, Root systems, Crop response, Organic compounds.

A strong influence of soil moisture on the release of 14C-labelled organic material into soil from cereal roots was shown by Barber and Martin (1976). There was a four-fold reduction of 14C-labelled water-soluble organic C in soil from pots regularly leached with distilled water compared with soil from pots which had no water addition, other than an initial wetting of the soil to 16% by weight with nutrient solution. Leaching also affected the composition of the water-soluble material. It was not possible to determine from these experiments the relationship between the soil water content and C release from the roots. This paper presents results for the release of organic C from wheat roots grown at three different soil water contents.

77:02G-157

SOIL MICROBIAL AND BIOCHEMICAL CHARACTERISTICS IN RELATION TO SOIL MANAGEMENT AND FERTILITY,

Verstraete, W., and Voets, J.P.
Gent University, Laboratory of General and Industrial Microbiology, Coupure 533, 9000 Gent, Belgium.
Soils Biology and Biochemistry, Vol. 9, No. 4, p 253-258, 1977. 5 tab, 18 ref.

Descriptors: Soil investigations, Fertilization, Nutrients, Fertilizers, Soil properties, Soil chemistry, Crop response, Mineralization, Organic matter, Sugarbeets.

From 1969 to 1974, two experimental fields were studied in terms of their soil microbial and biochemical characteristics in relation to soil management practice and crop yields. Of the various microbial and biochemical properties measured soil phosphatase, saccharase, beta-glucosidase and urease activities, N mineralization and soil respiration were found valuable to characterize the soils. These characteristics increased with increasing soil organic matter, clay and CaCO3 content. They also revealed a strong effect of organic fertilization. Multiple regression analyses indicated that the alkalinity and the humus content of the soil largely determined the magnitude of these characteristics. The regression analyses also showed that the yields of winter wheat were related positively to phosphatase activity while the sugarbeet yields were related negatively to soil urease activity.

77:02G-158
SULFUR OXIDATION AND RESPIRATION IN 54-YEAR-OLD SOIL SAMPLES,
Bollen, W.B.
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Soil Biology and Biochemistry, Vol. 9, No. 6, p 405-410, 1977. 3 tab, 15 ref.

Descriptors: Sulfur, Respiration, Sampling, Oxidation, Soil chemistry, Soil investigations, Soil properties, Soil tests, Soils.

Soil samples in dry storage for 54 years were shown to retain their ability to respire and to oxidize S. Three of the soils had lower S-oxidizing capacity and three oxidized more S at 1 g kg -1 than did the samples when originally collected. When the experiment was repeated with all apparatus sterilized by autoclaving and S sterilized in flowing steam, a greater proportion of the S was oxidized. This was not due to heat treatment of the S. In all cases, S additions and incubation resulted in a lowering of the soil pH, suggesting that Thiobacillus thiooxidans was responsible and had survived the prolonged storage. When the soils, before and after incubation, were added to Thiobacillus media, only Gram-positive bacteria, mostly Bacillus spp., were found.

77:02G-159
EFFECT OF NITROGEN DIOXIDE ON NITRITE OXIDATION AND NITRATE-OXIDIZING POPULATIONS IN SOIL,
Ghiorse, W.C., and Alexander, M.
Cornell University, Department of Agronomy, Laboratory of Soil Microbiology, Ithaca, New York 14853.
Soil Biology and Biochemistry, Vol. 9, No. 5, p 353-355, 1977. 2 fig, 9 ref.

Descriptors: Nitrogen, Nitrites, Oxidation, Soils, Soil investigations.

When nitrogen dioxide was added to soil at a rate equivalent to 51 mu g N g -1 soil, the nitrite formed was oxidized logarithmically. The numbers of nitrite-oxidizing microorganisms also increased logarithmically, but the final count was too low to account for the amount of nitrite metabolized. In soil treated with NO2 at a rate equivalent to 106 mu g N g -1, the nitrite formed was oxidized, but the counts of autotrophic nitrite oxidizers did not rise. Discrepancies between predicted bacterial numbers and nitrifying activity were also noted in soils amended with nitrite.

77:02G-160
SALINITY AND NITROGEN MINERALIZATION IN SOIL,
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Indian Agricultural Research Institute, Division of Soil Science and Agricultural Chemistry, New Delhi 110012.
Soil Biology and Biochemistry, Vol. 9, No. 5, p 333-336, 1977. 5 tab, 22 ref.

Descriptors: Salinity, Saline soils, Nitrogen, Mineralization, Nitrification, Ammonification, Urea, Salts, Soil amendments.

The effects of salinity on ammonification have been reviewed. It is suggested that ammonification could be due to the protolytic action of water and the influence of added salts on ammonification might be due to their effects on the degree of dissociation of water. The process of nitrification, however, is believed to be due to autotrophic organisms. Depending on the amounts applied to soil, nitrification has been found to be retarded, suppressed or inhibited completely by salt addition. This experiment was made to re-examine the effects of salinity on ammonification, nitrification and mineral N accumulation of native soil N and N added in farm compost, mustard oil cake or urea. The experiment was run over a long period.

77:02G-161

STUDIES OF NITROGEN IMMOBILIZATION AND MINERALIZATION IN CALCAREOUS SOILS--I. DISTRIBUTION OF IMMOBILIZED NITROGEN AMONGST SOIL FRACTIONS OF DIFFERENT PARTICLE SIZE AND DENSITY,

Ladd, J.N., Parsons, J.W., and Amato, M.
Commonwealth Scientific and Industrial Research Organization, Division of Soils,
Glen Osmond, South Australia 5064.
Soil Biology and Biochemistry, Vol. 9, No. 5, p 309-318, 1977. 5 fig, 5 tab, 27 ref.

Descriptors: Nitrogen, Mineralization, Calcareous soils, Soils, Soil investigations, Soil texture, Soil density, Glucose, Wheat, Soil amendments, Soil moisture, Soil chemistry.

Studies of the relative availability of nitrogenous components of soils have mostly been chemically based. Of the chemically "defined" components, acid-hydrolyzable amino acid-N appears to contribute most in inorganic-N is judged by the amounts of N lost from this organic-N pool during periods of net mineralization. However, measurements of the percentage decrease of N from soil chemical fractions show that no component is consistently of greater biological availability.

77:02G-162

STUDIES OF NITROGEN IMMOBILIZATION AND MINERALIZATION IN CALCAREOUS SOILS--II. MINERALIZATION OF IMMOBILIZED NITROGEN FROM SOIL FRACTIONS OF DIFFERENT PARTICLE SIZE AND DENSITY,

Ladd, J.N., Parsons, J.W., and Amato, M.
Commonwealth Scientific and Industrial Research Organization, Division of Soils,
Glen Osmond, South Australia 5064.
Soil Biology and Biochemistry, Vol. 9, No. 5, p 319-325, 1977. 1 fig, 5 tab, 23 ref.

Descriptors: Nitrogen, Mineralization, Calcareous soils, Soils, Soil investigations, Soil texture, Soil density, Glucose, Wheat, Soil amendments, Soil moisture, Soil chemistry.

$^{15}NO_3(-)$ was immobilized in a calcareous sandy soil and a calcareous clay soil each incubated with glucose and wheat straw. Net mineralization of organic-15N was more rapid in the sandy soil, irrespective of C amendment, and in soils amended with glucose. Intermittent drying and wetting of soils during incubation stimulated mineralization of 15N-labelled and native soil organic-N in all treatments. The availability (percentage mineralization) of recently-immobilized 15N consistently exceeded that of the native soil N. Ratios of the availability of labelled and unlabelled N were similar in the sandy and clay soils but varied according to C amendment, drying and wetting cycle and incubation period.

77:02G-163

EFFECT OF BIURET CONTENT ON TRANSFORMATION OF UREA NITROGEN IN SOIL,

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New Delhi 1100 12, India.
Soil Biology and Biochemistry, Vol. 9, No. 3, p 173-175, 1977. 2 tab, 16 ref.

Descriptors: Urea, Nitrogen, Nutrients, Fertilizers, Fertilization, Soil chemistry, Nitrites.

The effect of the biuret content on transformations of urea-N was studied in a sandy loam (pH 7.7). While biuret did not affect urea hydrolysis, it inhibited the conversion of $NH_4(+)$ to $NO_2(-)$ and the subsequent oxidation of $NO_2(-)$ to $NO_3(-)$. This resulted in the accumulation of larger amounts of both $NH_4(+)$-N and $NO_2(-)$-N in soil as compared to soil receiving urea alone. The results suggest that biuret impurity in urea fertilizer is likely to enhance nitrite toxicity.

77:O2G-164

PHOSPHATASES IN SOILS,

Eivazi, F., and Tabatabai, M.A.
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Soil Biology and Biochemistry, Vol. 9, No. 3, p 167-172, 1977. 4 fig, 4 tab, 26 ref.

Descriptors: Soils, Soil investigations, Soil chemistry, Soil chemical properties, Phosphates, Alkaline soils.

Most studies on phosphatase activity in soils have been concerned with acid phosphatase. This study was conducted to determine the activity of phosphomonoesterases (acid and alkaline phosphatases), phosphodiesterase, and "phosphotriesterase". The results indicate that acid phosphatase is predominant in acid soils and that alkaline phosphatase is predominant in alkaline soils. With universal buffer, the pH optima of phosphodiesterase and phosphotriesterase were at pH 10. The activities of these phosphatases in soils were much lower than those of the acid and alkaline phosphatases. Studies on the effects of various soil treatments on the activity of phosphatases in soils indicated that air-drying increased the activity of acid phosphatase and phosphotriesterase, decreased the activity of alkaline phosphatase, but did not affect the activity of phosphodiesterase.

77:O2G-165

NITROGEN ISOTOPE DISCRIMINATION IN DENITRIFICATION OF NITRATE IN SOILS,

Blackmer, A.M., and Bremner, J.M.
Iowa State University, Department of Agronomy, Ames, Iowa 50011.
Soil Biology and Biochemistry, Vol. 9, No. 2, p 73-77, 1977. 2 fig, 4 tab, 21 ref.

Descriptors: Nitrogen, Denitrification, Nitrates, Soils, Soil investigations, Soil chemistry, Isotopes, Soil chemical properties.

Nitrogen isotope discrimination during denitrification in soils of nitrate containing natural concentrations of 14N and 15N was studied by determining the amount and the 15N content of nitrate-N and (nitrate + nitrite)-N in nitrate-treated soils incubated under anaerobic conditions (He atmosphere) for various times after treatment with glucose to promote denitrification. Analyses performed showed that the nitrate-N lost on incubation of these soils could largely be accounted for as products of denitrification.

77:O2G-166

FACTORS INFLUENCING THE LOSS OF ORGANIC CARBON FROM WHEAT ROOTS,

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Commonwealth Scientific and Industrial Research Organization, Division of Soils, Glen Osmond, South Australia 5064.
Soil Biology and Biochemistry, Vol. 9, No. 1, p 1-7, 1977. 6 tab, 18 ref.

Descriptors: Carbon, Wheat, Root systems, Soils, Soil investigations, Crop response, Soil microorganisms.

Wheat plants were grown in an atmosphere containing 14CO2 at temperatures of 10 C or 18 C for periods from 3-8 weeks. The plant roots were maintained under sterile or nonsterile conditions in soil contained in sealed pots which were flushed to displace respired 14CO2. The 14C content of the shoots, roots and soil was measured at harvest. The loss of 14C from the roots, expressed either in terms of total 14C recovered from the pots or 14C translocated to the roots, ranged from 14.3-22.6%, mean 17.3% or 29.2-44.4%, mean 39.2%, respectively.

77:O2G-167

NATURE OF THE ORGANIC COATING ON SAND GRAINS OF NONWETTABLE GOLF GREENS,

Miller, R.H., and Wilkinson, J.F.
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Soil Science Society of America Journal, Vol. 41, No. 6, p 1203-1204, November-December, 1977. 1 fig, 14 ref.

Descriptors: Sand, Soils, Soil texture, Soil investigations, Turf, Soil profiles.

The organic coating of nonwettable sand grains from localized dry spots on sand golf greens was extracted with 5% NaOH. An infrared spectrum of resin purified, freeze-dried extract was similar to spectra of soil fulvic acids. All other supporting data such as solubility, color, failure to precipitate upon acidification, noncrystalline nature, and a high extinction coefficient were consistent with the conclusion that the organic coating was fulvic acid. The relationship of the synthesis of fulvic acids to basidiomycete hyphae in the affected soil layer is discussed.

77:02G-168
PHYSICAL PROPERTIES OF FLY ASH-AMENDED SOILS,
Chang, A.C., Lund, L.J., Page, A.L., and Warneke, J.E.
California University, Department of Soil Science and Agricultural Engineering, Riverside, California 92502.
Journal of Environmental Quality, Vol. 6, No. 3, p 267-270, July-September, 1977. 2 fig, 7 tab, 9 ref.

Descriptors: Fly ash, Soils, Soil investigations, Soil properties, Soil physical properties, Soil amendments, Soil water, Bulk density, Hydraulic conductivity.

Fly ash from a coal-fired power generating plant was mixed with five California soils at rates of 0, 2.5, 5.0, 10.0, 25.0, and 50.0% by volume. The physical properties related to the agronomic use of fly ash-amended soils were characterized by determining water-holding capacity, bulk density, hydraulic conductivity, and modulus of rupture on laboratory compacted soil cores. The moisture release characteristics of each mixture were also determined. Results indicated that a small amount of fly ash added to soils does appear to affect some measured physical properties of soils. At application rates >25%, there was a consistent increase in water-holding capacity (except a Domino loam soil), and a decrease in bulk density and modulus of rupture in all soils tested. The hydraulic conductivity increased with small amounts of fly ash, but declined rapidly as fly ash volume increased. Although fly ash application increased the water-holding capacity of soils, the amount of water available to the plant did not change significantly. At a low application rate, fly ash amendment appeared useful in improving certain agronomic properties of soils.

77:02G-169
NITRIFICATION IN THREE SOILS AMENDED WITH ZINC SULFATE,
Wilson, D.O.
Georgia University, Department of Agronomy, Georgia Station, Experiment, Georgia 30212.
Soil Biology and Biochemistry, Vol. 9, No. 4, p 277-280, 1977. 3 fig, 2 tab, 11 ref.

Descriptors: Soils, Soil investigations, Zinc, Nitrification, Soil properties, Soil chemistry, Soil chemical properties, Nitrogen.

The introduction of metals into soils by such routes as land application of sewage sludge and the deposition of airborne particulates from mining operations can significantly increase the native soil concentration of these metals. Heavy metals are commonly present in domestic sewage sludge at rather high concentrations and often at extremely high concentrations in industrial sludges. Elevation of the metal content of agricultural soils is of particular concern because of possible toxic effects on plant growth and other biological processes. Zinc is considered one of the metals most likely to produce phytotoxicity as a result of sludge application to soil (Webber, 1972). Since soils exhibit a wide range of physical and chemical properties, it is difficult to compare and extrapolate results of various workers with respect to the effects of Zn on soil N mineralization processes. Reported here are the results of a study relating nitrification to various rates of Zn added to three agriculturally important soils.

77:02G-170

ACETYLENE INHIBITION OF NITROUS OXIDE REDUCTION AND MEASUREMENT OF DENITRIFICATION AND NITROGEN FIXATION IN SOIL,

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Soil Biology and Biochemistry, Vol. 9, No. 3, p 177-183, 1977. 9 fig, 1 tab, 23 ref.

Descriptors: Denitrification, Nitrogen, Nutrients, Soil moisture, Soil chemistry, Soils, Soil investigations.

Reduction of N2O in moist soil was inhibited completely by 10(-2) atm C2H2 and partially by 10 (-5) atm C2H2. The effect of C2H4 was 100,000,000 times less than that of C2H2. Denitrification of NO3(-) occurred in anaerobically or aerobically incubated waterlogged soil and in anaerobic but not in aerobic moist soil.

77:02G-171

NITROGEN FERTILIZATION I. NITRATE ACCUMULATION AND LOSSES UNDER CONTINUOUS CORN CROPPING,

Hahne, H.C.H., Kroontje, W., and Lutz, J.A., Jr.

Virginia Polytechnic Institute and State University, Department of Agronomy, Blacksburg, Virginia 24061.

Soil Science Society of America Journal, Vol. 41, No. 3, p 562-567, May-June, 1977. 4 fig, 5 tab, 30 ref.

Descriptors: Nitrogen, Fertilizers, Fertilization, Nutrients, Corn, Crop response, Soils, Soil investigations, Irrigation, Irrigation effects, Soil texture.

Selected treatments were chosen from three field experiments with corn to determine effects of N rates on the vertical distribution of nitrates in the soil. The experiments were located on three different soil types and corn was grown for 5 consecutive years. Irrigation was a variable in two of the experiments. Appreciable amounts of NO3-N accumulated in the soils when the optimum rate of 140 kg N/ha at Blacksburg and Charlotte Courthouse and 168 kg N/ha at Orange had been exceeded. Amounts of vertical distributions of NO3-N accumulations were highly dependent on soil type, and on amounts of irrigation and rainfall. Lowest NO3-N accumulations and highest NO3-N losses were encountered in the Cecil fsl. An increase in NO3-N was found in the Davidson clay loam whereas no loss or gain was observed in the Groseclose silt loam.

77:02G-172

CHARGE CHARACTERISTICS OF SPODIC HORIZONS,

Laverdiere, M.R., and Weaver, R.M.

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Soil Science Society of America Journal, Vol. 41, No. 3, p 505-510, May-June, 1977. 5 fig, 5 tab, 22 ref, 2 equ.

Descriptors: Soils, Soil investigations, Soil properties, Organic matter, Adsorption.

Surface charge properties of six Spodosol Bir horizons, enriched in sesquioxides and organic matter, were investigated by acid-base potentiometric titrations and ion adsorption measurements. The results indicate that the horizons have electrochemical properties similar to constant surface potential colloids as the sign and magnitude of the net charge were dependent upon the pH and indifferent electrolyte concentration of the ambient solution. The pH values at which the net surface charge underwent reversal ranged from 4.2 to 4.9, and the values obtained by acid-base potentiometric titrations agreed fairly well with those obtained by ion adsorption measurements.

77:02G-173

ERODIBILITY OF SELECTED CLAY SUBSOILS IN RELATION TO PHYSICAL AND CHEMICAL PROPERTIES,

Romkens, M.J.M., Roth, C.B., and Nelson, D.W.
Agricultural Research Service, Sedimentation Laboratory, Oxford, Mississippi.
Soil Science Society of America Journal, Vol. 41, No. 5, p 954-960, September-October, 1977. 2 fig, 6 tab, 21 ref.

Descriptors: *Soil erosion, *Subsoil, *Physical properties, *Chemical properties, *Clays, *Erodibility (subsoils), Laboratory tests, Regression analysis, Chemical analysis, Soils, Equations, Soil properties, Soil physics, Chemistry.

Predictions of soil erodibility factors for selected clay subsoils were studied in relation to physical and chemical properties. Erodibility factors were determined from soil erosion rates on scalped surfaces during a series of simulated rainstorms. Subsoils were analyzed for their textural, chemical, and mineralogical composition. A predictive model, derived from previously gathered data of 46 surface soils, was used to determine the significance of soil properties in predicting subsoil erodibility. Weighted linear regression analysis using data from surface soils of the test model and 7 selected subsoils indicated that a textural parameter and the percent of iron plus aluminum extractable with citratedithionite-bicarbonate (CDB) were significant prediction properties of erodibility for these clay subsoils. Multiple linear regression yielded a prediction equation with a coefficient of multiple determination of R sq = 0.90.

77:02G-174

FACTORS INFLUENCING THE CRUST TEST FOR IN SITU MEASUREMENT OF HYDRAULIC CONDUCTIVITY,

Baker, F.G.
Wisconsin University, Department of Soil Science, Madison, Wisconsin.
Soil Science Society of America Journal, Vol. 41, No. 6, p 1029-1032, November-December, 1977. 1 fig, 5 tab, 14 ref.

Descriptors: *Hydraulic conductivity, *Permeability, *On-site investigations, Soil water, Soil water movement, Soils, Soil properties, Soil physics, Soil physical properties, Testing, Testing procedures, Soil science, Crust tests.

Field trials using the crust test were used to determine the influence of five parameters on the saturated and unsaturated hydraulic conductivity values measured on two soils of different structure. These factors were: (1) the diameter, (2) the height of the soil pedestal used in the test, (3) the degree of soil wetness at which k was measured, (4) soil structure, and (5) operator effects. Diameter and height were found to strongly affect measurement when they had low values. These two design factors were dependent on the wetness and structure of the soil. Operator differences were small.

77:02G-175

SOLUTE DISTRIBUTION PROFILES COMPUTED WITH STEADY-STATE AND TRANSIENT WATER MOVEMENT MODELS,

Wierenga, P.J.
New Mexico State University, Department of Agronomy, University Park, New Mexico.
Soil Science Society of America Journal, Vol. 41, No. 6, p 1050-1055, November-December, 1977. 8 fig, 23 ref.

Descriptors: *Hydraulic conductivity, *Solutes, *Soil water movement, *Model studies, Mathematical models, Moisture content, Pressure head, Fertilizers, Pesticides, Salts, Irrigation, Dispersion, Analytical techniques, Soil water, Soil physics, Soil science, Miscible displacement, Finite difference analysis.

A comparison was made between two numerical models for simultaneous movement of water and salts in soil profiles. In the first model, the water content and flux were constant during irrigation with time or depth (steady-state model). In the second model, the water contents and fluxes changed with time and depth following each infiltration according to the hydraulic properties of the soil (transient model). From a comparison between data obtained with the two models, it was shown that both techniques yield comparable results when concentrations are plotted versus cumulative drainage. Measured effluent concentration distributions from columns periodically irrigated with labeled water also compared well with effluent concentration distributions computed with the steady-state model.

77:02G-176
SALT EFFECTS ON THE HYDRAULIC PROPERTIES OF A SWELLING SOIL,
Dane, J.H., and Klute, A.
Colorado State University, Department of Agronomy, Fort Collins, Colorado.
Soil Science Society of America Journal, Vol. 41, No. 6, p 1043-1049, November-December, 1977. 10 fig, 1 tab, 24 ref.

Descriptors: *Soils, *Soil physical properties, *Hydraulic conductivity, *Salts, Hydraulic properties, Electrolytes, Salinity, Hydraulic gradient, Tensiometers, Pressure head, Loads (forces), Water retention, Swelling soil.

The effects of soil solution composition on the hydraulic conductivity, K, and the volumetric soil solution content, theta, were measured with mixed NaCl-CaCl2 solutions. The total electrolyte concentration, C, and the sodium adsorption ratio, SAR, characterized the applied solutions. Steady-state flow cells were constructed with provision for (1) measurement of the volumetric flux of the solution phase during saturated and unsaturated flow conditions, (2) measurement of the volumetric soil solution content by gamma attenuation, (3) tensiometers for hydraulic gradient and pressure head, h, measurement, (4) application of an external load on the soil, and (5) measurement of bulk volume changes. Soil samples were subjected to sequences of solutions varying in C from 1,000 meq/liter to 10 meq/liter at constant SAR values of 0, 5, 15, 25, and 40, respectively. Hydraulic conductivity decreases occurred during the first sequence of decreasing C at fixed SAT values equal to or greater than 5. The higher the SAR value, the greater the decrease in K with decreasing C. The K decreases occurred at all volumetric soil solution contents within the range of experimental data. Increases in theta, at given h values, and decreases in bulk density (pb), occurred simultaneously with the decrease in K. Greater changes in K and theta, and smaller changes in pb occurred in the soil subjected to a higher external load. The K and pb decreases and the theta increases were to a great extent irreversible, for example, when C was increased subsequently at a fixed SAR value, K, pb, and theta did not regain their initial values. Substantial increases in K were obtained, however, if the soil was air dried, sieved, and repacked into the flow cell.

SECTION VII

WATER CYCLE

WATER AND PLANTS (GROUP O2I)

77:O2I-001
EFFECT OF WATER STRESS DURING DIFFERENT STAGES OF GROWTH OF SOYBEAN,
Sionit, N., and Kramer, P.J.
Pahlavi University, Chiraz (Iran).
Agronomy Journal, Vol. 69, p 274-278, March-April, 1977. 5 fig, 1 tab, 15 ref.

Descriptors: *Moisture stress, *Plant growth, *Crop response, *Soybean, Water requirements, Drought, Flowering, Germination, Photoperiodism, Seeds, Crop production.

Two varieties of soybean (Glycine max, L. Merr.; "Ransom" and "Bragg") were studied to determine the effects on yield of controlled water stress at various stages of development. The plants were grown in a controlled environment chamber at 28/17 C with a 8 9-hour photoperiod at 450 hlx and an interrupted dark period which was then suspended for 7 days to induce flowering. Water stress was applied to plant groups during flower induction, flowering, pod formation and pod filling. Leaf water during stress dropped as low as -23 bars but returned to approximately normal after rewatering. Leaves were more susceptible to drought at later stages of growth, probably because they were already approaching senescence. Plants stressed during flower induction and flowering produced fewer flowers, pods and seeds than controls because of a shortened flowering period and abortion of some flowers. The greatest reduction of pods and seeds at harvest was due to stress during early pod formation, but the yield as measured by seed weight was most affected by stress during early formation and pod filling. Stress did not affect the oil or protein content of seeds, although total oil and protein produced per plant were less because of lower seed yields.

77:O2I-002
SOIL WATER-ROOT RELATIONS IN WHEAT: WATER EXTRACTION RATE OF WHEAT ROOTS THAT DEVELOPED UNDER DRY AND MOIST CONDITIONS,
Sharma, R.B., and Ghildyal, B.P.
Leeds University, Department of Plant Sciences, (England).
Agronomy Journal, Vol. 69, p 231-233, March-April, 1977. 2 fig, 2 tab, 8 ref.

Descriptors: *Soil water, *Soil-water-plant relationships, *Root systems, *Absorption, *Wheat, Dry farming, Soil moisture, Soil water movement, Clay loam, Root development, Root zone, Plant morphology, Consumptive use.

A greenhouse experiment was conducted in Pantnagar, India, to determine whether the root systems of wheat grown under different soil water conditions differed in capacity to extract water from the soil. The water extraction rate per unit root volume was measured for two wheat (Treticum aestivum L.) genotypes grown for 60 days after sowing in pots maintained under three soil water tension regimes of 0.3-0.8, 2.0-2.5, and 4.0-4.5 bars. Under study were the one-gene dwarf Snalika RR-21 and three-gene drawf UP 301; the soil was silty clay loam of the Mollisol order. Sixty days after sowing, the transpirational losses under different soil water tension regimes were measured for 12 days by covering the pots with polyethylene sheet and weighing. Root volume and total root water extracted decreased significantly for both genotypes. Results suggest that root systems which develop under relatively dry soil conditions extract more soil water on a unit root volume basis than those in moist conditions. Findings also indicate that roots under dry conditions develop a more intricate morphology and exploit the soil water more completely.

77:02I-003
SIMULATION OF NITROGEN MOVEMENT, TRANSFORMATIONS, AND PLANT UPTAKE IN THE ROOT ZONE,
Davidson, J.M., Rao, P.S.C., and Selim, H.M.
Florida University, Department of Soil Science, Gainesville, Florida.
Proceedings of National Conference on Irrigation Return Flow Quality Management, Colorado State University, Fort Collins, Colorado, p 9-18, May 16-19, 1977.
7 fig, 1 tab, 28 ref, 13 equ.

Descriptors: Simulation analysis, Model studies, Nitrogen, Soil water, Soil water management, Irrigation, Nitrification, Denitrification, Mineralization.

Two simulation models, a detailed research-type and a conceptual management-type, for describing the fate of nitrogen in the plant root zone are discussed. Processes considered in both models were: one-dimensional transport of water and water-soluble N-species as a result of irrigation/rainfall events, microbiological N-transformations, and uptake of water and nitrogen species by a growing crop. The research-type model involves a finite-difference approximations (explicit-implicit) of the partial differential equations describing one-dimensional water flow and convective-dispersive NH4 and NO3 transport, along with simultaneous plant uptake and microbiological N-transformations. Ion-exchange (adsorption-desorption) of NH4 was also considered. The microbiological transformations incorporated into the model describe nitrification, denitrification, mineralization and immobilization. All transformation processes were assumed to be first order kinetic processes. The numerical solution was flexible in its soil surface boundary conditions, as well as initial conditions for soil water content and nitrogen concentration distributions in the soil profile. The solution can also be used for nonhomogeneous or multilayered soil systems. The research-type model involves a detailed description of the individual process and requires a large number of input parameters, most of which are frequently unavailable. Because of this a more simple management-type model was developed. Several simplifying assumptions were introduced into the management model. This model requires a minimal amount of input data by the user, and provides a gross description of the behavior of various nitrogen species in the plant root zone.

77:02I-004
LOCAL SOLUTIONS TO DRAINAGE PROBLEMS,
Johnstone, W.R.
Westlands Water District, Fresno, California.
Proceedings of National Conference on Irrigation Return Flow Quality Management, Colorado State University, Fort Collins, Colorado, p 293-295, May 16-19, 1977.

Descriptors: Saline water, Salinity, Return flow, Drainage water.

Throughout the San Joaquin Valley the installation of on-farm tile systems can intercept and collect saline subsurface drainage water and thereby reduce or eliminate the damage from high water tables. Five subareas in the San Joaquin and Tulare Lake Basins of the San Joaquin and Tulare Lake Basins of the San Joaquin Valley have individually developed local solutions for disposing of saline subsurface drainage water collected within the subareas.

77:02I-005
RESPONSE OF LEAF WATER POTENTIAL TO PRESSURE CHANGES AT THE ROOT SURFACE OF CORN PLANTS,
Nulsen, R.A., Thurtell, G.W., and Stevenson, K.R.
Guelph University, Department of Land Resource Science, Ontario, Canada, NIG 2WI.
Agronomy Journal, Vol. 69, No. 6, p 951-954, November-December, 1977. 4 fig, 15 ref.

Descriptors: Roots, Root systems, Corn, Soil water, Soil moisture, Transpiration, Crop response.

The nature of the hydraulic continuum between the roots and leaves of intact plants requires further study to improve our understanding of the effect of pressure changes. A large pressure chamber was designed to apply hydrostatic pressure to the roots of intact corn plants. The chamber permitted application of up to 6 bars pressure and allowed for in situ watering of the plants. Changes in leaf water potential resulting from changes in pressure applied to the roots were monitored in situ using a thermocouple dewpoint hygrometer. Responses of leaf water potential were consistently between 0.94 and 1.19 times the change in applied pressure, regardless of whether the pressure was being increased or decreased. When pressure was applied to very turgid plants, leaf water potential increased until it reached a value equal to the osmotic pressure of expressed xylem sap. Some time after this value was reached water droplets appeared on the leaf surface. The experiments showed that the hydraulic system within intact plants acts as a true continuum in that pressure changes at one end of the system are faithfully manifested at the other end of the system. If such changes are not observed some additional mechanism must be operating.

77:02I-006
CROP SALT TOLERANCE----CURRENT ASSESSMENT,
Maas, E.V., and Hoffman, G.J.
United States Department of Agriculture, Agricultural Research Service, United States Salinity Laboratory, Riverside, California.
Journal of the Irrigation and Drainage Division, American Society of Civil Engineers, Vol. 103, No. IR2, p 115-134, June 1977. 1 fig, 1 tab, 160 ref.

Descriptors: Salts, Salt tolerance, Agriculture, Crop response, Salinity, Saline soils, Saline water.

An extensive literature review of all available salt tolerance data was undertaken to evaluate the current status of our knowledge of the salt tolerance of agricultural crops. In general, crops tolerate salinity up to a threshold level above which yields decrease approximately linearly as salt concentrations increase. Our best estimate of the threshold salinity level and yield decrease per unit salinity increase is presented for a large number of agricultural crops. The methods of measuring appropriate salinity and plant parameters to obtain meaningful salt tolerance data and the many plant, soil, water, and environmental factors influencing the plant's ability to tolerate salt are examined.

77:02I-007
ROLE OF CHANGES IN SOLUTE CONCENTRATION IN MAINTAINING FAVORABLE WATER BALANCE IN FIELD-GROWN COTTON,
Cutler, J.M., Rains, D.W., and Loomis, R.S.
California University, Department of Agronomy and Range Science, Davis, California.
Agronomy Journal, Vol. 69, No. 5, p 773-779, September-October, 1977. 5 fig, 49 ref.

Descriptors: Cotton, Crop response, Soil water, Soil moisture, Irrigation, Irrigation effects, Crop production, Agriculture.

Cotton shows various adaptive responses to water deficits, including alterations in cellular osmotic concentrations. The role of changes in solute concentration in maintaining favorable water balance in field-grown cotton was evaluated under wet and dry irrigation treatments. The experiments were conducted with a fine loamy mixed, calcareous thermic-Typic Torriorthents soil in a semi-arid environment. Leaf diffusive resistance, measured by a resistance porometer, was unaffected by leaf water potential while the typical response to light was maintained. Leaf blade elongation rate was less in plants with low leaf water potential. The rate was maximal in the early evening and depressed during the midday water potential minimum and at night. Some blade enlargement occurred during time intervals when leaf water potentials were as low as -19 to -23 bars.

77:02I-008
TRANSPIRATION EFFECTS ON LEACHING FRACTIONS,
Meiri, A., Kamburov, J., and Shalhevet, J.
The Volcani Center, Agricultural Research Organization, Bet Dagan, Israel.
Agronomy Journal, Vol. 69, No. 5, p 779-782, September-October, 1977. 2 fig, 2 tab, 9 ref.

Descriptors: Leaching, Infiltration, Soil water, Soil moisture, Soil water movement, Saline water, Irrigation water, Salinity, Salts, Seepage.

Water uptake by plants during the processes of infiltration and redistribution may introduce considerable errors in actual leaching when calculations are based on pre-irrigation soil water deficit. The objective of the study reported here was to measure and demonstrate the importance of this water uptake in causing a reduction in the actual leaching.

77:02I-009
ESTIMATING LEAF WATER POTENTIAL IN SAFFLOWER,
Sepaskhah, A.R.
Pahlavi University, College of Agriculture, Department of Irrigation, Shiraz, Iran.
Agronomy Journal, Vol. 69, No. 5, p 894-896, September-October, 1977. 1 fig, 14 ref.

Descriptors: Crop production, Greenhouses, Laboratory tests, Laboratory equipment, Leaves.

The pressure chamber technique is used for rapid measurements of plant water potential. Comparison of this method with thermocouple psychrometer technique is required at various stages of growth for different crops. Xylem water potential estimated by pressure chamber and leaf water potential measured by thermocouple psychrometer were correlated for safflower leaves at vegetative and flowering stages of growth in greenhouse conditions. The results of the two methods were linearly related for both growth stages but the equations were different at the 1% level. The values of ordinate intercept were nearly equivalent to the xylem sap osmotic potentials at both stages of growth.

77:02I-010
RESPONSE OF OATS TO WATER DEFICIT. I. PHYSIOLOGICAL CHARACTERISTICS,
Sandhu, B.S., and Horton, M.L.
South Dakota State University, Department of Plant Science, Brookings, South Dakota.
Agronomy Journal, Vol. 69, No. 3, p 357-360, May-June, 1977. 6 fig, 21 ref.

Descriptors: *Oats, *Moisture stress, *Moisture deficit, *Plant physiology, *Crop response, Growth stages, Stomata, Soil-water-plant relationships, Photosynthesis, Irrigation practices, Plant growth, Planting management, Leaves.

A study was conducted to determine the effects of water stress on certain physiological processes of spring oats (Avena sativa L.) under field conditions. Plants were subjected to water deficits for 9 to 11 days at the boot stage, at anthesis through early grain formation stage and at both stages in combination. Relative leaf water content (RLWC) according to the relative turgidity method was used as a measure of water deficit, and a diffusion porometer was used to monitor lead diffusion resistance (LDR). An 80% decline in the net photosynthetic rate (NPR), as measured using an infrared gas analyzer, resulted from severe water stress at all stages. A decline in RLWC was followed by LDR increases, due to siomatal closure induced by water deficits. Both LDR and RLWC recovered in 1 to 6 days after rewatering. Stress during the boot stage reduced photosynthetic sensitivity to subsequent stress at the anthesis through early grain formation stage, with NPR recovering more gradually and incompletely after that. Plants stressed only during the boot stage, then adequately watered, had higher NPR than controls. Since the LDR and NPR of oats have acute sensitivity to plant water deficits, these parameters may help determine permissible water deficit limits and irrigation scheduling.

77:02I-011
RESPONSE OF OATS TO WATER DEFICIT. II. GROWTH AND YIELD CHARACTERISTICS,
Sandhu, B.S., and Horton, M.L.
South Dakota State University, Department of Plant Science, Brookings, South Dakota.
Agronomy Journal, Vol. 69, No. 3, p 361-364, May-June, 1977. 5 tab, 19 ref.

Descriptors: *Crop response, *Oats, *Moisture deficit, *Plant growth, *Crop production, Moisture stress, Plant physiology, Growth stages, Root development, Root distribution, On-site investigations, Height, Planting management, Soil-water-plant relationships, Stomata.

Spring oats (Avena sativa L.) were subjected to water stress for 9 to 11 days under field conditions to evaluate growth and yield response to water deficits at certain stages. Plants were grown on pachic udic haploborolls soil (Lismore silty clay loam) in large pots (120-litre garbage cans) buried in the center of a field. Water stress applied at the boot stage and/or the anthesis through early grain formation stage decreased plant height and number of florets per panicle. Stress at anthesis through early grain formation caused more floret sterility and fewer heads at maturity. Deficits at all stages decreased the yield of straw, tops without panicles, panicles, kernels and dehulled kernels. Kernel yield was depressed 20% and 58%, respectively, with stress at booting and anthesis through grain filling; combined stress caused 67% yield decline. Plants under soil water stress rooted to a greater depth and had accelerated growth and profuse tillering when rewatered. Management under both dryland and irrigated conditions should emphasize irrigation during the anthesis through early grain formation stage, when water stress is especially dangerous.

77:02I-012
PREDICTION OF LATE SEASON NITRATE-NITROGEN CONTENT OF SUGARBEET PETIOLES,
Giles, J.F., Ludwick, A.E., and Reuss, J.O.
South Dakota State University, James Valley Research and Extension Center,
Redfield, South Dakota 57469.
Agronomy Journal, Vol. 69, No. 1, p 85-88, January-February, 1977. 6 fig, 1 tab, 8 ref.

Descriptors: Nitrates, Nitrogen, Sugarbeets, Nutrients, Fertilizers, Fertilization, Colorado.

Nitrate nitrogen levels in sugarbeet petioles have been used as an aid to diagnose nutritional status of the plants. The purpose of this study was to evaluate a theoretical approach to the prediction of the rate of change in NO3(-)N concentration of sugarbeet petioles. Petiole samples were collected from sugarbeet N fertilizer trails conducted over a 2-year period on cooperator farm sites in central and eastern Colorado. Results showed the NO3(-)N concentration of sugarbeet petioles through the growing season decreased exponentially. The rate of change was a function of soil NO3(-)N content (0-120 cm depth) measured in the spring and the amount of N applied as preplant fertilizer. Calculation of the rate of change with this function and the measurement of one early petiole sample enables the prediction of the NO3(-)N concentration during the remainder of the growing season.

77:02I-013
INTERACTIONS OF LEAD AND CADMIUM ON METAL UPTAKE AND GROWTH OF CORN PLANTS,
Miller, J.E., Hassett, J.J., and Koeppe, D.E.
Argonne National Laboratory, Argonne, Illinois.
Journal of Environmental Quality, Vol. 6, No. 1, p 18-20, January-March, 1977. 4 tab, 21 ref.

Descriptors: Lead, Cadmium, Heavy metals, Crop response, Corn, Crop production, Greenhouses.

Short term plant accumulation and growth effects of Pb and Cd added to soil separately and in combination were investigated with corn grown in a loamy sand under greenhouse conditions. A tendency for soil Pb to increase both the plant Cd concentration and the total Cd uptake of the corn shoots was observed. Conversely, soil Cd reduced the total Pb uptake and in some cases the Pb concentration in the corn shoots. Both Pb (125 and 250 mu g/g soil) and Cd (2.5 and 5 mu g/g soil) reduced the vegetative growth of the corn shoots, and a positive interaction of the two metals on growth was noted.

77:02I-014
WATER UPTAKE BY PLANTS: I. DIVIDED ROOT EXPERIMENT,
Herkelrath, W.N., Miller, E.E., and Gardner, W.R.
United States Geological Survey, Water Resources Division, 345 Middlefield Road,
Menlo Park, California 94025.
Soil Science Society of America Journal, Vol. 41, No. 6, p 1033-1038, November-December, 1977. 13 fig, 22 ref, 5 equ.

Descriptors: Soil water, Soil moisture, Root systems, Root zone, Root development, Crop production.

The influence of soil water content and soil water potential upon root water uptake was investigated in a controlled laboratory environment. Water extraction rates by roots of winter wheat were measured in situ in a soil column instrumented with a gamma-ray attenuation water-content meter, tensiometers, and psychrometers. In addition, the leaf water potential was measured with an in situ leaf hygrometer. In order to measure the vertical distribution of water uptake, the column was divided into five sections by wax layers which were penetrated by roots, but which prevented movement of water between sections in the soil.

77:02I-015
WATER UPTAKE BY PLANTS: II. THE ROOT CONTACT MODEL,
Herkelrath, W.N., Miller, E.E., and Gardner, W.R.
United States Geological Survey, Water Resources Division, 345 Middlefield Road, Menlo Park, California 94025.
Soil Science Society of America Journal, Vol. 41, No. 6, p 1039-1042, November-December, 1977. 7 fig, 1 tab, 6 ref.

Descriptors: Model studies, Root development, Root systems, Soil water, Soil moisture, Simulation analysis.

In the standard analysis of root water uptake, it is assumed there is a constant root membrane resistance in series with a soil resistance which is dependent upon the soil moisture diffusivity. The relation of root extraction rate to soil water content and to soil water potential predicted by this standard model was compared to the results of divided root experiments. The extraction rates predicted by the theory were as much as eight times larger than the measured values. A reasonable fit between theory and experiment could only be obtained by assuming in the theoretical calculations that the rooting density was 100 times smaller than that measured in the experiments.

77:02I-016
IRRIGATION APPLICATION DEPTHS FOR OPTIMUM CROP PRODUCTION,
DeBoer, D.W., Brosz, D.D., and Wiersma, J.L.
South Dakota State University, Department of Agricultural Engineering, Brookings, South Dakota.
Transactions of the American Society of Agricultural Engineers, Special Edition, Vol. 20SW, p 1067-1069, December 20, 1977. 4 fig, 4 tab.

Descriptors: Sprinkler irrigation, Soil moisture, Corn, Crop production, Grains (crops), Application methods, Water utilization, Surface irrigation, Irrigation water, Evapotranspiration, South Dakota, Tensiometers.

Corn was irrigated using three (2.5 cm, 5.0 cm and 7.5 cm) net irrigation depths to determine the effect of application depth on grain yield, water utilization efficiency and soil water movement. Grain yields and water utilization efficiencies were not affected by the application depths. The average rate of water removal from a 90 cm soil profile during July and August was 0.54 cm/day.

77:02I-017
WATER RELATIONS OF COTTON. II. CONTINUOUS ESTIMATES OF PLANT WATER POTENTIAL FROM STEM DIAMETER MEASUREMENTS,
Huck, M.G., and Klepper, B.
United States Department of Agriculture, Agricultural Research Service, Southern Region,
Agronomy Journal, Vol. 69, No. 4, p 593-597, July-August, 1977. 3 fig, 19 ref.

Descriptors: Cotton, Sampling, Crop response, Plant growth, Plant physiology, Plant population.

Information about plant water potential is often required at very frequent intervals in studies with small numbers of plants. Two methods for inferring plant water potential continuously and nondestructively are described for cotton plants. Both methods require continuous monitoring of stem diameter and occasional destructive sampling of tissue for determination of water potential by conventional methods. The computed results are compared with experimental measurements of plant water potential.

77:02I-018
COMPARATIVE STUDIES OF SOME INLAND SALINE AQUATIC ECOSYSTEMS IN NORTH DAKOTA,
Wali, M.K.
North Dakota University, Department of Biology, Project Reclamation, Grand Forks, North Dakota.
North Dakota Water Resources Research Institute, Research Project Technical Completion Report, Part 1, Report Number WI-221-033-76, Project Number A-031-NDAK, July 1970- June 1974, p. 1-58. 19 fig, 15 tab, 61 ref, 1 append.

Descriptors: North Dakota, Ecosystems, Saline water, Dissolved oxygen, Sediment-water interfaces, Saturation, Sediments, Sampling, Trace elements, Biomass, Temperature, Sago pondweed.

Potamogeton pectinatus L. is a very important wildlife food species, a submerged, marl forming macrophyte and grows as a natural monospecies community in Fox Lake, North Dakota. The water, sediment, dissolved oxygen, temperature and productivity relationships were studied in this small, shallow lake. The characteristics of aerobic and anaerobic sediments in Fox Lake and the North Dakota transect are discussed in terms of their effects on the nutrient concentrations. Chelation of cations by dissolved organic materials in the water and absorbed on the marl was found to be a possibility, especially for trace elements. Carbonate (marl) formation and bicarbonate utilization were found to be of major importance in the maintenance and productivity of the monotypic P. pectinatus community in Fox Lake.

77:02I-019
EFFECT OF REDOX POTENTIAL AND PH ON THE UPTAKE OF CADMIUM AND LEAD BY RICE PLANTS,
Reddy, C.N., and Patrick, W.H., Jr.
Louisiana State University, Department of Agronomy, Baton Rouge, Louisiana 70803.
Journal of Environmental Quality, Vol. 6, No. 3, p 259-262, July-September, 1977.
8 fig, 2 tab, 21 ref.

Descriptors: Cadmium, Lead, Rice, Heavy metals, Sediments, Saturated soils.

Redox potential and pH are two of the major factors influencing the mobilization and immobilization of heavy metals in flooded soils and sediments, and their availability to plants. A system developed for growing plants in soil suspensions where redox potential and pH can be controlled was used to study the uptake of cadmium (Cd) and lead (Pb) by rice plants. Uptake of Cd and Pb by root and shoot tissue, and their translocation from root to shoot, was determined at six different redox potentials (-200, -100, 0, +100, +200, and +400 mV) and four pH values (5, 6, 7, and 8). The effects of redox potential and pH on the levels of water-soluble Cd and Pb in the soil suspensions were also studied. Almost all Cd entering the rice plants accumulated in the shoots. Total Cd uptake and shoot uptake increased with an increase in suspension redox potential and a decrease in pH. Water-soluble Cd in the soil suspension was significantly correlated with total plant Cd and Cd uptake by shoot. Total Pb uptake, including Pb associated with the roots, decreased with an increase in suspension redox potential and pH.

SECTION VIII

WATER CYCLE

EROSION AND SEDIMENTATION (GROUP 02J)

77:02J-001
USE OF A VERSATILE EXPERIMENTAL SYSTEM FOR SOIL EROSION STUDIES,
Walker, P.H., Hutka, J., Moss, A.J., and Kinnell, P.I.A.
Commonwealth Scientific and Industrial Research Organization, Division of Soils, Canberra (Australia).
Soil Science Society of America Journal, Vol. 41, No. 3, p 610-612, May-June, 1977. 3 fig, 10 ref.

Descriptors: *Soil erosion, *Simulated rainfall, *Laboratory tests, Sheet erosion, Erosion, Erosion rates, Raindrops, Slopes, Streams, Runoff, Sediment transport, Bed load, Discharge (sediments), Rainfall, Rainfall simulators, Impact (rainfall), Soil science.

A laboratory facility for the study of soil erosion was described. Rainfall from a modular system supplied raindrops at near terminal velocity to prepared soil beds set in a flume with slope adjustable up to 30%. A comparison was made of erosion under overland flow alone and of storm rains of the same intensity (discharge), but of different energy levels. Raindrop impact in runoff flow was a powerful agency in promoting soil transport and inhibiting rill formation. Bed load movement was important in the transport of sand grains, even where the runoff was disturbed by raindrops.

77:02J-002
BED LOAD SAMPLER FOR STREAMS WITH SANDY BED,
Racotch, A., and Sagi, R.
Technion-Israel Institute of Tech., Faculty of Agricultural Engineering, Haifa (Israel).
Journal of the Hydraulic Division, American Society of Civil Engineers, Vol. 103, No. HY8, p 923-928, August 1977. 3 fig, 9 ref, 1 append.

Descriptors: *Bed load samplers, *Sampling, *Equipment, *Sediment transport, Bed load, Beds, Streams, Streamflow, Sands, Sediments, Sedimentation, Sedimentology.

Technical and operational considerations led to the idea of using a simple pit sampler in combination with a weighting instrument as a possible and inexpensive arrangement for bed load measuring purposes. In order to avoid large construction and collecting containers, it was decided to design the opening/instrument combination for particles having nominal (diameter of spheres that equal the number of particles considered and their total volume) diameters less than 3 mm, making the unit suitable for streams with sandy beds. The proposed instrument was described. The sensing element is built in the form of a bucket, subdivided into two compartments and pivoted over a knife edge. The bucket tips whenever one of the compartments fills up to a preset quantity of material. The material is tipped into the collecting container and the empty compartment is simultaneously exposed to the material entering the opening. The design of the shape and the dimensions of the bucket were based on an analytical investigation of a mathematical model. The analysis permitted determination of the parameters of the bucket and the position of the pivot. Emphasis was placed on automatic performance of the whole system in the sense that no person has to assist the measuring unit at the time of operation.

77:02J-003
INCIPIENT TRANSPORT OF FINE GRAINS AND FLAKES BY FLUIDS-EXTENDED SHIELDS DIAGRAM,
Mantz, P.A.
Imperial College of Science and Technology, Department of Civil Engineering, London (England).
Journal of the Hydraulics Division, American Society of Civil Engineers, Vol. 103, No. HY6, Proceedings Paper 12992, p 601-615. June 1977. 4 fig, 3 tab, 30 ref, 2 append.

Descriptors: *Bed load, *Hydraulics, *Sedimentation, *Shear stress, *Cohesionless soils, Streamflow, Silts, Laboratory tests, Sediments, Data collections.

Experiments on the incipient transport from flat sediment beds in water streams of four grades of fine cohesionless granular solids and six grades of fine cohesionless flaky solids were reported. The fine granular data were compared with data obtained from recent smaller-scale laboratory experiments, and all data were plotted on a Shields diagram. An "extended Shields diagram," which is applicable to cohesionless solids only, was proposed. The fine flaky data were compared with collected data concerned with the incipient transport of coarse two-dimensional solids or flakes. The data again were adapted to the Shields representation. The incipient transport fluid conditions for granular and flaky solids (which solids were chosen as being representative of extreme shape limits) were contrasted.

77:02J-004
CHANGING NEEDS AND OPPORTUNITIES IN THE SEDIMENT FIELD,
Wolman, M.G.
Geological Survey, Water Resources Division, Baltimore, Maryland.
Water Resources Research, Vol. 13, No. 1, p 50-54, February 1977. 21 ref.

Descriptors: *Sedimentation, *Erosion, *Sediment transport, *Sediment yield, Reviews, Evaluation, Model studies, Hydrologic properties, Hydrologic data, Environmental effects.

Information on the processes of erosion and sedimentation, while sometimes sufficient for gross estimates of yield, remains inadequate for modern environmental management. Little is known about sequential processes involved in the systems of erosion and sedimentation, and practice and theory require attention to unsteady or discontinuous erosion and transportation as sediments move from source through channel systems with intermittent periods of storage. While climatic and hydrologic variations markedly affect yield, transport and deposition thresholds of erosion of cohesive materials and sequences of such effects remain unclear. The highly variable temporal and spatial character of erosion and sedimentation processes must be emphasized in the predictive exercise of environmental impact assessment. Validation or testing of the predictive capacity of our current knowledge can only be achieved by field observation. This does not imply massive data collection programs but rather an integration of model building, laboratory study, and continuity of study in carefully selected field areas.

77:02J-005
DETERMINATION OF SEDIMENT YIELD BY TRANSFERRING RAINFALL DATA,
Smith, J.H., Davis, D.R., and Fogel, M.
Arizona University, Department of Systems and Industrial Engineering, Tucson, Arizona.
Water Resources Bulletin, Vol. 13, No. 3, p 529-541, June 1977. 2 fig, 17 ref.

Descriptors: *Sediment yield, *Reservoir silting, *Model studies, *Arizona, Rainfall, Reservoir storage, Reservoirs, Dead storage, Decision making, Equations, Risks, Mathematical studies, Numerical analysis, Methodology, Estimating, Sediment discharge.

A methodology for obtaining the optimal design value to allow for sediment storage in a reservoir was presented for the situation where no data on sediment loads in the incoming streams are available. Information concerning the amount of sediment delivered to the reservoir over its lifetime was obtained by a sediment yield model which uses data on rainfall amount and duration obtained from a nearby experimental watershed. Bayesian Decision Theory was used to obtain the optimal storage requirements in order to consider the natural variation of rainfall and the sampling error due to the short rainfall record available. The normally difficult calculations involved were made tractable by the use of simplifications and approximations which were valid in the context of the problem. Results showed that sediment storage requirements can be calculated in this manner and that consideration of the uncertainties involved leads to a shortage requirement substantially larger than that calculated without such consideration.

77:02J-006
MANAGEMENT GUIDELINES FOR CONTROLLING SEDIMENTS, NUTRIENTS, AND ADSORBED BIOCIDES IN IRRIGATION RETURN FLOWS,
Carter, D.L., and Bondurant, J.A.
United States Department of Agriculture, Snake River Conservation Research Center, Kimberly, Idaho.
Proceedings of National Conference on Irrigation Return Flow Quality Management, Colorado State University, Fort Collins, Colorado, p 143-152, May 16-19, 1977.
3 tab, 36 ref, 2 equ.

Descriptors: Furrow irrigation, Sediments, Return flow, Erosion, Nutrients, Surface irrigation, Runoff, Irrigation, Tailwater, Irrigation systems.

Sediments in irrigation return flows arise mostly from furrow erosion, and nearly all nutrients and biocides in surface irrigation return flows, except those applied directly to the water, are adsorbed to the sediments. Therefore, controlling erosion and sediment loss in these surface return flows also controls the nutrients and biocides. There are three general management approaches for controlling sediments in return flows. The first is to eliminate surface runoff by using irrigation methods that produce no runoff. These methods include properly designed and operated sprinkler systems, basin, trickle, and some border and level furrow methods. The second approach is to eliminate or reduce erosion by controlling the slope in the direction of irrigation, the furrow stream size, the run length, the irrigation frequency and duration, and tillage practices. The third is to remove sediments from surface return flows by controlling the tailwater and utilizing sediment retention basins. All three approaches are applicable and necessary for adequate control in most irrigated areas. Available technology needs to be integrated and applied to these approaches. Research to develop improved irrigation systems and methods, improved irrigation water distribution systems, and better field management practices, and research on design and operational criteria for sediment retention basins are needed.

77:02J-007
ECONOMIC ANALYSIS OF ON-FARM METHODS FOR CONTROLLING SEDIMENT AND NUTRIENT LOSSES,
Lindeborg, K.H., Conklin, L., Long, R.B., and Michalson, E.L.
Idaho University, Moscow, Idaho.
Proceedings of National Conference on Irrigation Return Flow Quality Management, Colorado State University, Fort Collins, Colorado, p 193-201, May 16-19, 1977.
16 tab, 3 ref.

Descriptors: Idaho, Model studies, Irrigation practices, Crop production, Erosion, Sedimentation, Irrigation, Water quality, Phosphorus, Nitrogen, Groundwater, Pollution.

Information from 150 farmers in the Boise and Magic Valley areas was collected relative to current crop production, tillage and irrigation practices, cost of production, and income from crop production. The physical and economic data were processed by a budget generating method allowing standardized procedures of estimating costs of operating machinery and equipment. Partial budgets for each important crop grown in the two areas were developed from the computer program. Representative farms were simulated for the two areas based on the partial budgets. The simulated farm sizes will be a measure of the profitability of the present farming operation under existing water management practices. The effects on farm net income of implementing erosion control practices on the farms, as well as by district, are analyzed using linear programming models. The analysis is based on two farm sizes in each area, and measures the effects on net farm income for a given set of rotation with increasing sedimentation loss, or alternately, a changing cropping pattern with a given lower limit of sediment loss with the resulting change in farm net income.

77:02J-008
NUTRIENT LOSSES IN SURFACE RUNOFF FROM A NATIVE PRAIRIE,
Timmons, D.R., and Holt, R.F.
United States Department of Agriculture--Agricultural Research Service, North Central Soil Conservation Service, Morris, Minnesota 56267,
Journal of Environmental Quality, Vol. 6, No. 4, p 369-373, October-December, 1977. 5 tab, 22 ref.

Descriptors: Nutrients, Fertilizers, Fertilization, Runoff, Minnesota, Snowmelt, Rainfall, Rainfall-runoff-relationships, Nitrogen, Phosphorus, Potassium, Sodium, Calcium, Chemical oxygen demand.

Nutrient losses in surface runoff from a native prairie were determined for 5 years. The prairie, dominated by little bluestem was on a Barnes loam soil in west-central Minnesota. Snowmelt runoff accounted for 80% of the average annual runoff. After spring thaw, rainfall caused appreciable runoff (37% of annual) during 1 year only. Depending on chemical parameter, 63 to 88% of the average annual nutrient loads were transported by snowmelt runoff. Average annual total nitrogen (N) and total phosphorus (P) losses were 0.8 and 1.1 kg/ha, respectively, and organic N and organic (+ hydrolyzable) P comprised 68 and 82% of their respective annual losses. Average annual cation losses ranged from about 0.1 to 1.8 kg/ha and, except for 1 year, were in the order K>Ca>Mg>Na. Average weighted concentrations for all parameters were higher for rainfall runoff than for snowmelt runoff. Nutrient losses from native prairie represent natural levels for comparing the effects of different land uses on nutrient loads in surface runoff.

77:02J-009
SOIL LOSS: AN OVERVIEW,
Kovda, V.A.
Moscow State University, Institute of Agrochemistry and Soil Science, Moscow Region, Union of Soviet Socialist Republics.
Agro-Ecosystems, Vol. 3, No. 3, p 205-224, June 1977. 3 tab, 12 ref.

Descriptors: Soils, Soil investigations, Soil erosion, Soil environment, Soil engineering, Soil management, Soil science, Environment, Land resources, Land management, Land use.

The earth's soil budget is analyzed and the causes of loss and degeneration are described. The main efforts to solve the problems of soil loss should be concentrated on: (a) the preparation of international guidelines for conservation policy; (b) declaration of an International Soil Conservation Decade; and (c) acceleration of and support for land assessment; (d) development of national planning for alternative land uses; (e) research to establish ecologically sound policies for land use and conservation.

77:02J-010
ERODIBILITY OF SOME MINNESOTA SOILS,
Young, R.A., and Mutchler, C.K.
Agricultural Research Service, Morris, Minnesota.
Journal of Soil and Water Conservation, Vol. 32, No. 3, p 180-182, July 1977.
3 tab, 22 ref.

Descriptors: *Erosion, *Minnesota, *Soils, *Erosion rates, *Soil erosion, Runoff, Bulk density, Equations, Silts, Montmorillonite, Hydrology.

Soil erodibility factors from 13 Minnesota soils were calculated based on measured soil loss and on runoff from standard simulated rainstorms. Regression analysis of erodibility on 10 soil characteristics plus runoff indicated that 5 soil variables-aggregate index, dispersion rate, bulk density, percent silt and very fine sand, and amount of montmorillonite in the soil-explained 90% of the variance in the calculated K values. When currently used K values obtained from the soil erodibility nomograph and SCS determinations were compared with the calculated K values, it was found that the currently used values underestimated the erodibility of 6 and overestimated the erodibility of 3 of the 13 soils tested.

77:02J-011
HELLEY-SMITH BED LOAD SAMPLERS,
Johnson, C.W., Engleman, R.L., Smith, J.P., and Hanson, C.L.
Agricultural Research Service, Boise, Idaho.
Journal of the Hydraulics Division, American Society of Civil Engineers, Vol. 103, No. HY10, p 1217-1221, October 1977. 2 fig, 1 tab, 9 ref, 1 append.

Descriptors: *Bed load samplers, *Sampling, *Idaho, *On-site investigations, *Sediment load, Instrumentation, Demonstration watersheds, Equipment, Sediment transport, Sediments, On-site tests, Testing, Testing procedures, Measurement.

This paper reported recent findings and experiences in using Helley-Smith bed load samplers in streams on the Reynolds Creek Experimental Watershed in southwest Idaho. Equipment and procedures developed in sampling during peak streamflow events were described. The 90-sq mile sagebrush rangeland watershed, with a main stream length of 16 miles (25.7 km), an elevation difference of 3,700 ft (1,130 m), and average streamflow rate of 21.5 cfs, is characterized by steep gravel-boulder streambeds with many outcrops of basalt and granite. The streams transport large quantities of sediment during rainfall and snowmelt events. Users of Helley-Smith bed load samplers, under conditions of high organic and sediment transport, should recognize the possible sampling error caused by clogging of standard sampler bags and instead use either larger bags or bags with a mesh larger than 0.2 mm. The samplers with standard small 0.2 mm mesh bags clogged very easily and drastically affected the sediment catch. The large sampler bags with 930 sq in of bag area, instead of 340 sq in caused no sampler operation problems and allowed sampling for longer periods to obtain larger samplers. Large 0.2 mm mesh bags are recommended for most uses.

77:02J-012
PROCEEDINGS OF THE NATIONAL SYMPOSIUM ON SOIL EROSION AND SEDIMENTATION BY WATER,
American Society of Agricultural Engineers
American Society of Agricultural Engineers, 2950 Niles Road, Saint Joseph, Michigan 49085.
Proceedings of the National Symposium on Soil Erosion and Sedimentation by Water, Palmer House, Chicago, Illinois, 151 p, December 12-13, 1977. 25 fig, 17 tab, 275 ref, 37 equ.

Descriptors: Soil erosion, Erosion, Sedimentation, Erosion control, Erosion rates, Sediment control, Sediment discharge, Sediment load, Sediment transport, Sedimentation, Sediments.

The results of numerous research projects and investigations are presented which focus upon defining appropriate technologies for alleviating soil erosion and sedimentation by water. Each year, 1 million acre-feet of sediment, the product of erosion, is deposited in reservoirs, occupying water-storage volume that cost 100 million dollars to develop. Additionally, sediment from construction clogs drainage ditches and storm sewers. Sediment from surface mines damages adjacent waterways, destroying aquatic life. Sediment from irrigated fields increases the turbidity of nearby streams and makes treatment for municipal uses difficult. Although agricultural erosion and sedimentation problems have received widespread attention for decades, the problem still persists. Methods to control erosion in 1940 are seldom acceptable in 1977. Massive changes in farm machinery, animal husbandry, and cropping have negated many methods of erosion control. New vegetative and mechanical methods for erosion control have been developed to solve problems in 1977. In recent years, besides experiencing an increased demand for clean water, there has been an increasing demand for new construction and for minerals and new sources of fossil fuels. Technology has been developed to control erosion and sedimentation from surface mines and construction sites.

77:02J-013
SEDIMENT PREDICTION IN THE EASTERN UNITED STATES,
Malcolm, H.R., Jr., and Smallwood, C., Jr.
North Carolina State University, Department of Civil Engineering, Raleigh, North Carolina.
Journal of the Water Resources Planning and Management Division, American Society of Civil Engineers, Vol. 103, No. WR2, Proceedings Paper 13340, p 285-298, November 1977. 6 fig, 2 tab, 13 ref, 2 append.

Descriptors: *Sedimentation, *Streams, *Lakes, *Model studies, Mathematical models, Equations, Urbanization, Drainage, Erosion, Forecasting, Planning, Channels, Lake sediments, Deposition (sediments), Sediment discharge, Sediment transport, Watersheds (basins), Erosion, Sedimentology.

Sediment discharge equations were derived for wooded, rural, urban, and severely exposed watersheds on the East Coast. The equations were used to model the impact of urbanization on sedimentation activity. The equations can be used in crude, but reasonably effective, modeling techniques to study some impacts of urbanization on streams and lakes. The equations confirmed and quantified the existence of a two-part urban sedimentation problem: one associated with erosion of denuded areas, and the other with the degradation of stream channels rendered unstable by extensive watershed changes. Two studies compared results with historical cases.

77:02J-014
RESOURCE ADEQUACY IN LIMITING SUSPENDED SEDIMENT DISCHARGES FROM AGRICULTURE,
Heady, E.O., and Meister, A.D.
Iowa State University, Center for Agricultural and Rural Development, Ames, Iowa 50011.
Journal of Soil and Water Conservation, Vol. 32, No. 6, p 289-293, November-December, 1977. 3 fig, 6 tab, 3 ref.

Descriptors: Computer programs, Model studies, Pollution, Agriculture, Water surface, Irrigation, Erosion, Sediments, Suspended sediments.

The Iowa State University national programming model was used to evaluate the economic impacts of controlling nonpoint pollution from agriculture and to assess whether environmental improvement goals could be met in conjunction with high agricultural exports. Alternatives analyzed included a base solution, high exports, land and water conservation, and environmental enhancement. High exports could be attained simultaneously under the land and water conservation alternative. Exports must be reduced, however, under the environmental enhancement alternative. To meet exports under the land and water conservation alternative, 10 million acres of wetlands would need to be converted to cropland. Returns to land would increase considerably under all alternatives other than the base solution. There would be wide variations among regions, however. In general, a relative redistribution of income from irrigated to drylands and from erosive to nonerosive farming regions would occur.

77:02J-015
FILTRATION OF NONHOMOGENEOUS SEDIMENT BY SIMULATED VEGETATION,
Hayes, J.C., and Barfield, B.J.
Kentucky University, Department of Agricultural Engineering, Lexington, Kentucky.
Presented at the 1977 Winter Meeting of the American Society of Agricultural Engineers, December 13-16, 1977, Palmer House Hotel, Chicago, Illinois, p 1-18. 7 fig, 2 tab, 14 ref, 24 equ.

Descriptors: Model studies, Sediment, Sedimentation, Sediment loads, Open channels, Simulation analysis, Hydrographs, Vegetation, Vegetation effects.

A nonsteady state model is presented for determining the sediment infiltration of an artificial grass filter under varying flow rates, sediment loads, particle sizes, channel slopes, and media density. Good agreement was found between predicted and observed profiles for given flow conditions and inflow hydrographs using laboratory data.

77:02J-016
SOIL LOSS EQUATION: DERIVATION FOR STEEP SLOPES,
Gregory, J.M., Johnson, H.P., and Kirkham, D.
Missouri University, Department of Agricultural Engineering, Columbia, Missouri.
Presented at the 1977 Winter Meeting of the American Society of Agricultural Engineers, December 13-16, 1977, Palmer House Hotel, Chicago, Illinois, p 1-29. 4 fig, 1 tab, 10 ref, 65 equ.

Descriptors: Model studies, Simulation analysis, Sediment transport, Erosion, Soil erosion.

An equation has been derived for the prediction of soil loss from areas with steep slopes. The equation compares favorably with the Universal Soil Loss Equation for flat slopes (0-20 percent) and agrees with experimental results in the literature for steep slopes (20-100 percent).

77:02J-017
PREDICTING SEDIMENT YIELD FROM AGRICULTURAL LAND,
Shelton, C.H.
Tennessee University, Department of Agricultural Engineering, Knoxville, Tennessee.
Presented at the 1977 Winter Meeting of the American Society of Agricultural Engineers, December 13-16, 1977, Palmer House Hotel, Chicago, Illinois, p 1-16. 4 fig, 3 tab, 6 ref, 3 equ.

Descriptors: Sediments, Sediment yield, Agriculture, Simulation analysis, Runoff, Soil erosion.

Three forms of sediment-yield prediction equations were developed and tested with data from 105 runoff events on five watersheds. Runoff volume accounted for variations in yield better than maximum 30-minute intensity rainfall, erosive-potential rainfall factor, or peak runoff rate; and the best prediction equation was obtained after logarithmic transformation of variables.

77:02J-018
WATER QUALITY LOADINGS DURING THIRTEEN STORMS ON THE CADDO RIVER, ARKANSAS,
Perrier, E.R., Westerdahl, H.E., and Nix, J.F.
United States Army Engineer District, Waterways Experiment Station, Environmental Effects Laboratory, Vicksburg, Mississippi.
American Society of Agricultural Engineers, Post Office Box 410, Saint Joseph, Michigan 49085, p 1-28. 5 fig, 11 tab, 14 ref.

Descriptors: Water quality, Sediments, Sedimentation, Sediment loads, Sedimentary basins, Arkansas.

Nonpoint source loadings of twenty-five selected water quality parameters have been described for thirteen storm events on the Caddo River drainage basin in Arkansas. These parameters were functionally related to on-site measurements although wide variation was attributable to hysteresis and the stochastic nature of the system.

77:02J-019
PREDICTION OF SEDIMENT BASIN PERFORMANCE,
Ward, A.D., Haan, C.T., and Barfield, B.J.
Kentucky University, Department of Agricultural Engineering, Lexington, Kentucky.
Presented at the 1977 Winter Meeting of the American Society of Agricultural Engineers, December 13-16, 1977, Palmer House Hotel, Chicago, Illinois, p 1-29. 11 fig, 2 tab, 17 ref, 12 equ, 1 append.

Descriptors: Model studies, Mathematical analysis, Simulation analysis, Sedimentation, Sediment control, Sediment load.

A mathematical model for simulating the sedimentation characteristics of detention basins is described. Using data generated by the model, the significant factors affecting basin trapping efficiency and peak sediment outflow concentrations are identified. Equations for predicting these factors are developed.

77:02J-020
THE ANSWERS MODEL: A PLANNING TOOL FOR WATERSHED RESEARCH,
Beasley, D.B., Monke, E.J., and Huggins, L.F.
Arkansas University, Department of Agricultural Engineering, Fayetteville, Arkansas.
Presented at the 1977 Winter Meeting of the American Society of Agricultural Engineers, December 13-16, 1977, Palmer House Hotel, Chicago, Illinois, p 1-21. 12 fig, 2 tab, 15 ref, 7 equ.

Descriptors: Model studies, Computer programs, Hydrology, Erosion, Soil erosion.

The ANSWERS model, a distributed parameter watershed hydrology and erosion simulator, is presented. The basic concepts and the pertinent component relationships are described. In addition, sample outputs from the ANSWERS model are included.

77:02J-021
ERODIBILITY OF SELECTED CLAY SUBSOILS IN RELATION TO PHYSICAL AND CHEMICAL PROPERTIES,
Romkens, M.J.M., Roth, C.B., and Nelson, D.W.
Agricultural Research Service, Sedimentation Laboratory, Oxford, Mississippi.
Soil Science Society of America Journal, Vol. 41, No. 5, p 954-960, September-October, 1977. 2 fig, 6 tab, 21 ref.
(See 77:02G-174)

77:02J-022
SOLVING THE SOIL EROSION PROBLEM,
Barlow, T.
Natural Resources Defense Council, Incorporated, 917 15th Street, N.W., Washington, D.C. 20005.
Journal of Soil and Water Conservation, Vol. 32, No. 4, p 147-149, July-August, 1977.

Descriptors: Erosion, Soil erosion, Water quality, Water pollution, Runoff.

Soil erosion is a serious national problem today. Air and water can be cleansed of pollutants, but when the topsoil is gone, the country is in real trouble. How serious is the erosion problem? Let me cite some reports and hearings from the past two years. And please note, these are not wild-eyed radicals speaking. They are agricultural scientists and farmers who work the land, the people who know best.

77:02J-023
EVALUATION OF WILD OAT STRAW AS A SOIL EROSION RETARDANT USING SIMULATED RAINFALL,
Singer, M.J., and Blackard, J.
California University, Department of Land, Air and Water Resources, Davis, California.
Agronomy Journal, Vol. 69, No. 5, p 811-814, September-October, 1977. 3 fig, 2 tab, 13 ref.

Descriptors: Erosion, Soil erosion, Rainfall, Oats, Runoff, Mulches.

Soil cover is recognized as an important factor in soil erosion control. This study was made to determine the quantitative relationship between cover percent for one cover type and soil loss under simulated rainfall. Data from this experiment are used to calculate a cover coefficient for wild oat straw similar to the "C" factor in the Wischmeier Universal Soil Loss Equation. The R, K, L, S, and P factors were kept constant during the experiments. A rainfall simulator was used in the laboratory to produce 30 min rainfall events of 76 mm/hour (3 in/hour) intensity on soil material at 9% slope. Under these conditions, wild oat straw significantly reduced sediment loss at cover levels of 50% or more. A significant reduction in runoff volume was observed for cover percentages exceeding 90%.

77:02J-024
INFLUENCE OF ENVIRONMENTAL PARAMETERS ON EDTA BIODEGRADATION IN SOILS AND SEDIMENTS,
Tiedje, J.M.
Michigan State University, East Lansing, Michigan 48824.
Journal of Environmental Quality, Vol. 6, No. 1, p 21-26, January-March, 1977. 4 fig, 3 tab, 20 ref.

Descriptors: Soils, Soil investigations, Soil texture, Sediments, Sedimentation, Chelation.

14C-EDTA (ethylenediaminetraacetate) was slowly degraded to 14CO2 by all soils tested from the major agricultural EDTA use areas; by soils varying in uses, pH, and texture; and by sediments from the Detroit River. EDTA degradation appears to be a result of cometabolism by established microbial populations. Production of 14CO2 from EDTA occurred under aerobic but not anaerobic conditions. No detectable quantities of intermediates accumulated under either condition. EDTA degradation followed first order kinetics for concentrations ranging from 0.4 to 90 ppm. Degradation was observed up to 1,000 ppm EDTA, the highest concentration tested. The date of sample collection had a marked effect on extent of degradation with the winter-collected samples showing greater than twice the degradation of summer-collected samples. The Q10 was two up to 30C. Initially degradation of 50C was limited, but after 9 weeks incubation the rate accelerated indicating the adaptation of thermo-tolerant EDTA-degrading populations. The extent of degradation among soils was variable; common values for 2 to 4 ppm of added 14C-EDTA mineralized were 13 to 45% after 15 weeks and 65 to 70% after 45 weeks.

77:02J-025
SOIL EROSION AND SEDIMENTATION BY WATER--AN OVERVIEW,
Foster, G.R., and Meyer, L.D.
Purdue University, Department of Agricultural Engineering, West Lafayette, Indiana.
Proceedings of the National Symposium on Soil Erosion and Sedimentation by Water, Palmer House, Chicago, Illinois, p 1-13, December 12-13, 1977. 53 ref.

Descriptors: Soil erosion, Erosion, Sediments, Rainfall, Water quality, Sediment load, Sediment transport.

Soil erosion and sedimentation by water primarily involve the processes of detachment, transportation, and deposition of sediment by raindrop impact and flowing water. Erosion and sedimentation are major problems that reduce the productivity of cropland, degrade water quality, carry polluting chemicals, and reduce the capacity of water conveyance structures. The erosion-sedimentation system is composed of upland and channel components. While the uplands act somewhat independently of the channels, the behavior of the channels is directly influenced by the upland inputs. Spatial and temporal variations in erosion are common with time lags in sediment yield as great as several decades. Climate, soil, topography, and land use are major factors influencing erosion and sedimentation.

77:02J-026
CURRENT SOIL EROSION AND SEDIMENT CONTROL TECHNOLOGY FOR RURAL AND URBAN LANDS,
Highfill, R.E., and Kimberlin, L.W.
United States Department of Agriculture, Soil Conservation Service, Washington, D.C.,
Proceedings of the National Symposium on Soil Erosion and Sedimentation by Water, Palmer House, Chicago, Illinois, p 14-22, December 12-13, 1977. 28 ref.

Descriptors: Erosion, Sediments, Water quality, Water resources, Agriculture, Erosion control, Sediment load.

Erosion and sedimentation are important factors in managing land and water resources. Agricultural land, especially cropland, produces the largest amount of sediment annually. The next largest source is geologic erosion. Range and forest lands and construction activities are about equal in the amount of sediment produced. Erosion control is important to maintain productivity on agricultural and forest lands and to aid in sediment pollution control. Procedures have been developed for predicting erosion and sediment yield. Technology is available to reduce the amount of erosion and sediment induced by water from most land areas. In some places, additional research or data are needed to improve the performance of erosion control systems or reduce the cost, or both. The quality of installation and maintenance of erosion control measures is still one of the major problem areas.

77:02J-027
POLITICAL, SOCIAL, AND ECONOMIC ASPECTS OF SOIL EROSION AND SEDIMENTATION CONTROL PROGRAMS,
Heft, F.E.
Ohio State University, Department of Agronomy, Ohio.
Proceedings of the National Symposium on Soil Erosion and Sedimentation by Water, Palmer House, Chicago, Illinois, p 23-30, December 12-13, 1977.

Descriptors: Economics, Erosion, Sediments, Soil erosion, Political aspects, Social aspects, Social values.

Recently, we have witnessed a sincere, dedicated, and sometimes fervent concern by our citizenry for our natural resource use and management policies. The most obvious of these concerns are couched in our environmental spectrum containing both realistic and unrealistic demands upon our political, social, and economic systems. Shrinking supplies of certain natural resources and the ability of our nation to retain a high degree of self-sufficiency has brought serious challenges to our management policies.

77:02J-028
PREDICTING SOIL EROSION,
Kimberlin, L.W., and Moldenhauer, W.C.
United States Department of Agriculture, Soil Conservation Service, Washington, D.C.,
Proceedings of the National Symposium on Soil Erosion and Sedimentation by Water, Palmer House, Chicago, Illinois, p 31-42, December 12-13, 1977. 26 ref.

Descriptors: Soil erosion, Erosion, Erosion rates, Sediment transport, Sedimentation.

Erosion of soil by water poses an increasing threat as needs for food and fiber production and space for social and economic necessities of a growing population and pressures to our Nation's land resources. The Universal Soil Loss Equation (USLE) developed through many years of cooperative efforts of the Agricultural Research Service, state experiment stations, and the Soil Conservation Service is a highly useful tool for predicting sheet and rill erosion under various conditions of land use and management. It is widely accepted and used by soil conservationists and others. However, there are some problems associated with its use and some additional needs to supplement its use in the field.

77:02J-029
PREDICTING SEDIMENT YIELDS,
Onstad, C.A., Mutchler, C.K., and Bowie, A.J.
United States Department of Agriculture, Agricultural Engineering Division, Morris, Minnesota.
Proceedings of the National Symposium on Soil Erosion and Sedimentation by Water, Palmer House, Chicago, Illinois, p 43-58, December 12-13, 1977. 50 ref, 14 equ.

Descriptors: Soil erosion, Erosion, Sediments, Sediment transport, Sediment load, Sediment discharge, Model studies.

Sediment yield is the amount of soil transported from a drainage basin. Studies for predictions of sediment yield have general uses, which include the following. Simulations are used to extend a short-term sampling program to an adequate data base to predict future watershed response to various land-use alternatives and as an ordered sequence of steps in time and space so that information gaps can be identified. The specific needs for sediment yield prediction are so varied that no single model could meet them without a great loss of efficiency. These needs generally fall into the categories of length of model event time, area to be simulated, and sediment sources. At present, many sediment yield models are available for use or have been used for various purposes.

77:02J-030
ESTABLISHING SOIL LOSS AND SEDIMENT YIELD LIMITS FOR AGRICULTURAL LAND,
Logan, T.J.
Ohio State University, Ohio Research and Development Center, Department of Agronomy, Ohio.
Proceedings of the National Symposium on Soil Erosion and Sedimentation by Water, Palmer House, Chicago, Illinois, p 59-68, December 12-13, 1977. 1 fig, 3 tab, 13 ref, 3 equ.

Descriptors: Agriculture, Soil erosion, Erosion, Sedimentation, Sediment discharge, Sediments, Sediment load.

Soil loss tolerance values, T-values, are currently based on annual gross erosion rates that can be tolerated and still maintain crop productivity. The major criterion used by Soil Conservation Service in establishing these values which range from 1 to 5 tons acre (-1) year (-1) is topsoil depth. The assumptions on which this criterion is based are reviewed. Soil loss in relation to sediment and nutrient watershed yields is discussed and criteria which might be used to establish tolerance values for sediment and nutrient loss abatement programs are given. Soil loss tolerances for sediment and nutrient loss reduction will likely be more restrictive than T-values and should be applied only to critical areas where the impact of these sources is greatest.

77:02J-031
SEDIMENTATION AND EROSION CONTROL IMPLICATIONS FOR WATER QUALITY MANAGEMENT,
Mulkey, L.A., and Falco, J.W.
United States Environmental Protection Agency, Technology Development and Applications Branch, Environmental Research Laboratory, Athens, Georgia.
Proceedings of the National Symposium on Soil Erosion and Sedimentation by Water, Palmer House, Chicago, Illinois, p 69-90, December 12-13, 1977. 11 fig, 4 tab, 34 ref, 20 equ.

Descriptors: Soil erosion, Erosion control, Water quality, Sediment transport, Simulation analysis.

Erosion and sedimentation, including sediment transport through a watershed system, play important but complex roles in water quality management. The most meaningful way to evaluate the relative effectiveness of various erosion control methods for water quality management is via continuous simulation models. If water quality goal attainment is attempted by application of source controls within some specified technology limits (including costs), however, a more simplistic approach may be used for analysis of this nonpoint source of environmental pollution. This paper focuses on the latter technique, but also presents the results of more sophisticated analysis methods for illustrative purposes.

77:02J-032
VEGETATIVE WATER EROSION CONTROL FOR AGRICULTURAL AREAS,
Mannering, J.V., and Fenster, C.R.
Purdue University, Department of Agronomy, Indiana.
Proceedings of the National Symposium on Soil Erosion and Sedimentation by Water, Palmer House, Chicago, Illinois, p 91-106, December 12-13, 1977. 3 fig, 11 tab, 27 ref.

Descriptors: Soil erosion, Erosion control, Sediment transport, Vegetation, Vegetation effects.

Methods whereby vegetation can effectively control water erosion are presented. Both crop residues and their management as well as growing vegetation are considered. Crop residue factors that determine their erosion control effectiveness includes (a) the type of crop, (b) the amount and type of residues produced, (c) whether or not residues are removed or left on the field and (d) the effect of residue placement by tillage systems.

77:02J-033
MECHANICAL EROSION CONTROL FOR AGRICULTURAL AREAS,
Jeschke, J.L., Moe, R.C., and Carmack, W.J.
United States Department of Agriculture, Soil Conservation Service, Lincoln, Illinois.
Proceedings of the National Symposium on Soil Erosion and Sedimentation by Water, Palmer House, Chicago, Illinois, p 107-115, December 12-13, 1977. 2 fig, 4 tab, 5 ref.

Descriptors: Soil erosion, Erosion, Erosion control, Agriculture, Terracing.

Mechanical erosion control is discussed as it relates to practice application on sloping cropland. Planning and design considerations for applying terraces, grade stabilization structures, and debris basins are presented. Special emphasis is placed on the problems involved in designing these practices to be compatible with current farming techniques. The benefits of using topographic maps produced by aerial surveys in planning and design of these practices are also discussed.

77:02J-034
PROBLEMS OF IMPLEMENTING EROSION CONTROL,
Hagen, W.R.
State Soil Conservation Committee, Waterville, Iowa 52170.
Proceedings of the National Symposium on Soil Erosion and Sedimentation by Water, Palmer House, Chicago, Illinois, p 116-124, December 12-13, 1977. 2 tab.

Descriptors: Soil erosion, Erosion, Erosion control, Sediment transport, Soil conservation.

The author cites personal involvement in soil and water conservation work on his own farm, during the formation years of the soil conservation movement in the United States to the present. Personal experiences in problems of implementing erosion control are shown, as well as progress in spite of those problems. Current problems in erosion control include (1) only partial community acceptance, (2) peer group pressure, (3) unsuitable equipment, (4) resistance to change, (5) economic burdens, and (6) damaging press coverage. To counteract these obstacles, the author suggests (1) continued use of accurate news releases, (2) continued education on natural resource problems, (3) election and appointment of public officials with a knowledge of and concern for natural resources, (4) passage of land use legislation, (5) imposing fines on blatant abusers of the land, (6) giving tax incentives to landowners who practice conservation and (7) increasing government cost-sharing for establishment of permanent soil conservation practices.

77:02J-035
EROSION AND SEDIMENT CONTROL IN URBANIZING AREAS,
Boysen, S.M.
United States Department of Agriculture, Soil Conservation Service, College Park, Maryland 20740.
Proceedings of the National Symposium on Soil Erosion and Sedimentation by Water, Palmer House, Chicago, Illinois, p 125-136, December 12-13, 1977. 7 fig, 8 ref.

Descriptors: Soil erosion, Erosion, Erosion control, Sediment control, Sediments, Urbanization.

The urban sediment control program in Maryland according to a recent United States Geological Survey report has caused a 60 to 80 percent reduction in construction site sediment yields between 1966 and 1974. The sediment control program, based on a set of basic principles, was developed and implemented beginning in Montgomery County in 1965. Technical principles for controlling erosion and sediment were also developed. The present state law requires that all development must have a sediment control plan approved by the soil conservation district before any construction begins.

77:02J-036
EROSION AND SEDIMENT CONTROL FOR COAL SURFACE MINE AREAS,
McCarthy, R.E.
Washington Irrigation and Development Company, Centralia, Washington 98531.
Proceedings of the National Symposium on Soil Erosion and Sedimentation by Water, Palmer House, Chicago, Illinois, p 137-145, December 12-13, 1977. 1 fig, 1 tab.

Descriptors: Mining, Water quality, Drainage, Erosion, Soil erosion, Erosion control, Sediments, Sediment control.

The elimination of the impact of a major coal surface mine on the water quality of adjacent waterways through the use of drainage systems, settling ponds, and a monitoring system for dispensing polymer electrolytes for chemical flocculation of suspended sediment is described.

77:02J-037
EROSION AND SEDIMENTATION ON IRRIGATED LANDS,
Bondurant, J.A.
Agricultural Research Service, Snake River Conservation Research Center, Kimberly, Idaho 83341.
Proceedings of the National Symposium on Soil Erosion and Sedimentation by Water, Palmer House, Chicago, Illinois, p 146-151, December 12-13, 1977. 13 ref.

Descriptors: Erosion, Soil erosion, Irrigation, Surface irrigation, Sediments, Sediment discharge.

Most erosion on irrigated land is caused by the irrigation itself. Surface irrigation--where water is applied directly to the surface as in furrow or border irrigation--can be very erosive. Data from southern Idaho show that large quantities of sediment may be generated within an irrigation system; however, less sediment may be returned to the river than is diverted with the water supply. Technology for reducing erosion from irrigated fields is available: irrigation systems may be modified or changed, fields may be leveled or profiled to nonerosive slopes, tillage operations can be reduced, vegetative filter strips and drain ditch elevation control will remove sediment, or sediment ponds may be used after runoff leaves the field.

77:02J-038
AN EROSION MODEL FOR ARID WILDLAND WATERSHEDS,
Wagenet, R.J., Grenney, W.J., and Jurinak, J.J.
Utah State University, Department of Soil Science, Logan, Utah.
Presented at the 1977 Winter Meeting of the American Society of Agricultural Engineers, December 13-16, 1977, Palmer House Hotel, Chicago, Illinois, p 1-22. 6 fig, 2 tab, 6 ref.

Descriptors: Computer programs, Model studies, Erosion, Soil erosion, Sediments, Heavy metals.

A nonsite specific computer model was developed to predict environmental metal distribution resulting from the erosion of stack derived emissions of a coal fired electric generating facility. Model predictions of sediment eroded Zn, Cd, Cr, Pb, and Hg are presented for a 25 year period, and show Hg and Cd to be of environmental concern while indigenous soil levels of Zn, Cr, and Pb greatly outweigh contributions expected from the generating facility.

77:02J-039
PREDICTION OF SEDIMENT TRANSPORT IN A GRASSED MEDIA,
Barfield, B.J., Tollner, E.W., and Hayes, J.C.
Kentucky University, Department of Agricultural Engineering, Lexington, Kentucky 40506.
Presented at the 1977 Annual Meeting of the American Society of Agricultural Engineers, June 26-29, 1977, North Carolina State University, Raleigh, North Carolina, p 1-23. 7 fig, 3 tab, 13 ref, 20 equ.

Descriptors: Model studies, Sediments, Sediment control, Sediment loads, Sediment transport, Vegetation, Vegetation effects.

A steady state model is presented for determining the sediment filtration capacity of a grass media under varying flow rates, sediment loads, particle sizes, flow durations, channel slopes, and media density. It is possible to use the model to predict the required media spacing, channel slope, and length of media to give a desired outflow concentration for given flow conditions.

77:02J-040
COMPARATIVE ERODIBILITY OF LOESS SOILS IN POLAND AND THE UNITED STATES,
Piest, R.F., and Ziemnicki, S.
United States Department of Agriculture, Agricultural Research Service, Watershed Research Unit, Columbia, Missouri.
Presented at the 1977 Winter Meeting of the American Society of Agricultural Engineers, December 13-16, 1977, Palmer House Hotel, Chicago, Illinois, p 1-29. 7 fig, 3 tab, 17 ref, 2 equ.

Descriptors: Erosion, Soil erosion, Iowa, Sediment transport, Erosion control, Erosion rates.

Historic erosion patterns between loess soil regions of Poland and southwestern Iowa were compared. A rational interpretation of the measured soil losses reported by various researchers was attempted through application of the Universal Soil Loss Equation. Gullying rates and causes in both countries were examined.

77:02J-041
A RUNOFF EROSIVITY FACTOR AND VARIABLE SLOPE LENGTH EXPONENTS FOR SOIL LOSS ESTIMATES,
Foster, G.R., Meyer, L.D., and Onstad, C.A.
Purdue University, Department of Agricultural Engineering, Lafayette, Indiana.
Transactions of the American Society of Agricultural Engineers, Vol. 20, No. 4, p 683-687, July-August, 1977. 1 tab, 15 ref.

Descriptors: *Soil erosion, *Sediment yield, *Watersheds (basins), *Mathematical models, Equations, Erosion, Sheet erosion, Rill erosion, Runoff, Estimating, On-site tests, Slopes, Analysis.

A runoff erosivity term was developed for the Universal Soil Loss Equation (USLE) from analysis of an erosion equation derived from basic erosion principles. The accuracy of erosion estimates for individual storms can be improved significantly by using a soil loss equation having separate terms for rill and interrill erosion. Also, such an equation can be used to estimate the amount of sediment from different slope segments and also the amount from the soil surface and from deeper within the soil profile. The analyses showed the potential of estimating soil loss using separate rill erosion and interrill erosion terms in an erosion equation. Research is needed to define precisely the relationship between rill erosion and runoff erosivity and that between interrill erosion and rainfall erosivity. The separate effects of cover, management, and supporting practices on rill and interrill erosion need to be established. The achievement of the mentioned goals promises to provide a flexible, useful, and accurate erosion equation based on sound erosion principles. In the meantime, basic erosion principles can be used as guidelines to adjust parameters in the USLE for more accurate soil loss estimates for specific time periods and situations.

77:02J-042
AN EROSION EQUATION DERIVED FROM BASIC EROSION PRINCIPLES,
Foster, G.R., Meyer, L.D., and Onstad, C.A.
Purdue University, Department of Agricultural Engineering, Lafayette, Indiana.
Transactions of the American Society of Agricultural Engineers, Vol. 20, No. 4, p 678-682, July-August, 1977. 28 ref.

Descriptors: *Soil erosion, *Watersheds (basins), *Theoretical analysis, *Mathematical models, Rill erosion, Sediment transport, Sediment yield, Sheet erosion, Erosion, Equations, Overland flow, Runoff, Rainfall, Erosion control, Land management, Shear stress.

An erosion equation was derived from the continuity equation for sediment transport and other basic equations describing rill and interrill erosion. The resulting equation is a useful model for explaining the behavior of the erosion process. The equation might serve as the basis for an operational equation for estimating soil loss for specific storms.

77:02J-043
EROSION OF THE TARKIO DRAINAGE SYSTEM, 1845-1976,
Piest, R.F., Elliott, L.S., and Spomer, R.G.
Agricultural Research Service, Columbia, Missouri.
Transactions of the American Society of Agricultural Engineers, Vol. 20, No. 3, p 485-488, May-June, 1977. 3 fig, 2 tab, 4 ref.

Descriptors: *Stream erosion, *Channel erosion, *Rivers, *Iowa, *Missouri, Runoff, Drainage, Soils, Soil texture, Loess, Degradation (slope), Degradation (stream), Scour, Cultivated lands, Agriculture, Gullies, Geomorphology, Slopes, Erosion, History.

Historic and geologic evidence indicated that channel and gully erosion was nearly nonexistent when the loess-mantled Tarkio Basin of southwestern Iowa and north--western Missouri was settled about 1845. The pattern of channel development-gleaned from old land surveys, records from drainage districts, highway bridge surveys, and other documents--is related to the intensity of agriculture and is linked complexly to the general runoff regimen and to changes in soil water content along channel boundaries. Some channel enlargement during the post-settlement period, 1845-1976, is quantified. Channel profile changes during recent years, 1939-1976, were reconstructed. The excessive scour in a channel reach of West Tarkio Creek was explained tentatively on the basis of geomorphic principles and differences in substrata erodibility.

77:02J-044
RUNOFF, EROSION, AND NUTRIENT MOVEMENT FROM INTERRILL AREAS,
Monke, E.J., Marelli, H.J., Meyer, L.D., and DeJong, J.F.
Purdue University, Department of Agricultural Engineering, Lafeyette, Indiana.
Transactions of the American Society of Agricultural Engineers, Vol. 20, No. 1, p 58-61, January-February, 1977. 4 fig, 6 tab, 9 ref.

Descriptors: *Runoff, *Erosion, *Nutrients, *Overland flow, *Rainfall, Laboratory tests, Simulated rainfall, Precipitation (atmospheric), Soil erosion, Suspended solids, Nitrogen, Phosphorus, Inflow, Soils, Loam, Silts, Sediments, Agriculture.

The influence of rainfall and overland flow on interrill erosion and associated nutrient losses was studied for flatland conditions. Interrill erosion rates were substantially large. However, amounts of eroded soil reaching actual stream systems may be greatly reduced, depending on the severity of storms. Interrill erosion rates can be decreased substantially by improved tilth. In soils with excellent tilth, the silt fraction in the eroded soil was higher than in the original soil, and the clay and sand fractions were lower. Although N and P concentrations in the soils with excellent tilth were quite high, losses of these nutrients in sediment runoff were low because of increased infiltration.

77:02J-045
AN ECONOMIC EVALUATION OF CROPLAND USE AS A CONTROL FOR SEDIMENT NONPOINT POLLUTION,
Wade, J.C., and Heady, E.O.
Iowa Agriculture and Home Economics Experiment Station, Ames, Iowa.
Agriculture and Environment, Vol. 3, No. 4, p 307-323, October 1977. 6 fig, 3 tab, 12 ref, 11 equ.

Descriptors: Sediments, Sedimentation, Economics, Model studies, Water quality, Agriculture, Pollution.

Substantial economic change occurs if national goals of sediment control are established. An environmental/economic model of national agricultural production and sediment--water quality analyses five alternative goals of sediment control to give insight into changes in farm production technologies, incomes, pollution levels, and consumer and producer costs in the 48 contiguous United States.

77:02J-046
NITROGEN AND PHOSPHORUS MOVEMENT FROM AGRICULTURAL WATERSHEDS,
Burwell, R.E., Schuman, G.E., Heinemann, H.G., and Spomer, R.G.
United States Department of Agriculture, Department of Soil Science, Agricultural Research Service, Columbia, Missouri 65201.
Journal of Soil and Water Conservation, Vol. 32, No. 5, p 226-230, September-October, 1977. 6 tab, 13 ref.

Descriptors: Nitrogen, Phosphorus, Nutrients, Fertilizers, Fertilization, Watersheds (basins), Iowa, Runoff, Erosion, Soil erosion.

A five-year study on Missouri Valley deep loess watersheds near Treynor, Iowa, to characterize the movement of nitrogen (N) and phosphorus (P) as influenced by applied fertilizer and conservation practices was conducted. Our report presents watershed budget-accounting information for measured N and P movement that included (a) corn crop use, (b) surface runoff losses, (c) deep percolation, and (d) subsurface discharge. Erosion control and the application of N and P fertilizer at rates recommended for annual crop use minimized losses of these nutrients from the watersheds.

SECTION IX

WATER CYCLE

CHEMICAL PROCESSES (GROUP O2K)

77:O2K-001
ION ACTIVITY PRODUCTS OF CALCIUM CARBONATE IN WATERS BELOW THE ROOT ZONE,
Suarez, D.L.
Agricultural Research Service, Salinity Laboratory, Riverside, California.
Soil Science of America Journal, Vol. 41, No. 2, p 310-315, March-April, 1977.
4 fig, 3 tab, 27 ref.

Descriptors: *Ions, *Soil water, *Calcium carbonate, *Arizona, *Calcareous soils, Calcite, Soil chemistry, Irrigation wells, Irrigation water, On-site investigations, Chemical precipitation.

A study was conducted to determine the pH, Ca(2+) and HCO3(-) relations in 28 well waters obtained from beneath fields in the Wellton-Mohawk Irrigation District of Arizona. Based on field measurements of pH, the mean CaCO3 ion activity product (IAP) was 11.3 x 10 to the minus 9th power (pIAP 7.95) with a standard error of 0.7 x 10 to the minus 9th power at field water temperatures of about 25C. The residence time of waters in the soil varies widely; results indicate a longer residence time is associated with greater ionic strength. The lack of a trend in pIAP vs. ionic strength indicates the kinetics of calcite equilibration (from super-saturation) is slow in soil-water systems. Further support for this was an average pIAP of 7.97 calculated from 35 water analyses obtained from wells in the Grand Valley of Colorado and by a pIAP value of 7.96 in a soil water sample from a lysimeter study. A pIAP value of 7.95 is suggested for use in predictive models when CaCO3 precipitation occurs. Waters experiencing rapid CO2 degassing (for example, surface exposure of drainage waters) would have higher IAP values and measurable rates of precipitation.

77:O2K-002
DISSOLUTION KINETICS OF CARBONATE ROCKS I, EFFECTS OF LITHOLOGY ON DISSOLUTION RATE,
Rauch, H.W., and White, W.B.
West Virginia University, Department of Geology and Geography, Morgantown, West Virginia.
Water Resources Research, Vol. 13, No. 2, p 381-394, April 1977. 15 fig, 4 tab, 36 ref.

Descriptors: *Carbonate rocks, *Solubility, *Laboratory tests, *Pennsylvania, Dolomite, Calcite, Limestones, Karst, Sedimentary rocks, Caves, Geomorphology, Rock properties, Rocks, Carbon dioxide, Water, Chemistry, Hydrogen ion concentration, Karst hydrology, Groundwater, Petrology.

Laboratory dissolution of Middle Ordovician rock samples from central Pennsylvania was studied at 23C and 1 atm carbon dioxide pressure. Carbonate dissolution rates were compared at 22% bicarbonate saturation with respect to both calcite and dolomite. The results showed that carbonate lithology exerts a strong influence on the dissolution rate and hence, on the degree of cavity development in karst aquifers. The dissolution rate is affected most significantly by dolomite and impurity content. The rate decreases as percentages of dolomite and disseminated insolubles increase. Maximum dissolution rates occur for carbonate rocks with 1.0-2.5% MgO content and with abundant silty streaks. The sparite content is related inversely to cave development but is independent of dissolution rates measured under the laboratory conditions adopted in this study.

77:02K-003

ESTIMATED ASSOCIATION CONSTANTS FOR SOME COMPLEXES OF TRACE METALS WITH INORGANIC LIGANDS,

Mattigod, S.V., and Sposito, G.
California University, Department of Soil and Environmental Science, Riverside, California 92521.
Soil Science Society of America Journal, Vol. 41, No. 6, p 1092-1097, November-December, 1977. 3 fig, 3 tab, 60 ref, 9 equ.

Descriptors: Soils, Soil investigations, Model studies, Heavy metals, Soil chemistry.

Chemical equilibrium studies of trace metals in soils by an ion-association model require reliable data on thermodynamic association constants for various metal-ligand complexes. Therefore, available experimental data at 25 C were compiled for complexes of the transition metal cations Mn2+, Fe2+, Ni2+, Cu2+, and Zn2+ with the ligands CO3(2-), HCo3(-), SO4(2-), HSO4(-), PO4(3-), HPO4 (2-), H2PO4(-), Cl(-), and OH(-). However, experimental values of the thermodynamic association constants for many of the complexes were not available. This lack of information was alleviated by employing the theoretical model of Kester and Pykowicz and the semiempirical models of Nieboer and McBryde, and Van Panthaleon Van Eck to make estimates of the as yet unmeasured association constants. These estimated constants were tabulated in a compact form along with the experimental values. This compilation of 100 association constants, although provisional, should prove helpful in a variety of studies on trace metal equilibria in soils until more reliable experimental data become available.

77:02K-004

SULFURIC ACID AS AN AMENDMENT FOR RECLAIMING SOILS HIGH IN BORON,

Prather, R.J.
United States Salinity Laboratory, Post Office Box 672, Riverside, California 92502.
Soil Science Society of America Journal, Vol. 41, No. 6, p 1098-1101, November-December, 1977. 1 fig, 3 tab, 29 ref.
(See 77:02G-154)

77:02K-005

NITRATE IN EFFLUENTS FROM IRRIGATED LANDS (ANNUAL REPORT),

Pratt, P.F., Biggar, J.W., Broadbent, F.E., et al.
Research Applied to National Needs, National Science Foundation, Washington, D.C. 20550.
Publication No. PB-275 673, July 1977. 91 p, 13 fig, 17 tab, 14 ref.

Descriptors: Nitrates, Nitrification, Chemical reactions, Denitrification, Irrigated land, Effluents, Irrigation, Nitrogen, Soil-water-plant relationships, Soil properties.

This report presents progress in the development of technologies for measurements of NO(-)3 leaching and denitrification and in our understanding of the factors that influence the quantities of nitrogen that go into various sinks. Research on various aspects of the nitrogen cycle in the soil-plant-water system are discussed, including: (1) nitrogen transformations with particular emphasis on denitrification; (2) crop utilization of nitrogen; (3) incorporation of nitrogen into and cycling in soil organic matter; (4) fluxes of water through the root zone; and (5) effects of soil profile properties on nitrogen leaching and denitrification.

SECTION X

WATER CYCLE

ESTUARIES (GROUP 02L)

77:02L-001
CROP TEMPERATURE REVEALS STRESS,
Jackson, R.D., Idso, S.B., Reginato, R.J., Ehrler, W.L.
Agricultural Research Service, Water Conservation Laboratory, Phoenix, Arizona.
Crops and Soils, Vol. 29, No. 8, p 10-13, June-July, 1977. 5 fig.

Descriptors: *Crop response, *Temperature, *Moisture stress, *Instrumentation, Crop production, Air temperature, Irrigation practices, Transpiration, Evaporation, Canopy, Satellites (artificial), Data collections, Farm management, Soil-water-plant relationships.

A plant with adequate soil moisture is able to transpire water and keep its leaves cooler than the surrounding air temperature; leaves transpire less and grow warmer as moisture becomes scarce. A thermal scanning device to measure crop stress has been developed; present and future technology of this type is described. Infrared thermometers can indirectly measure surface temperatures by measuring the radiant thermal energy emitted from a leaf surface. To calculate the stress degree day figure, a farmer measures the temperature of the crop canopy and the air just above the crop an hour or so after solar noon. Readings from aircraft or satellites require two measuring times, one just before dawn for the minimum air temperature and one after noon for the maximum. Results of measurements from several crops indicate that as the midday canopy temperature increases in comparison to the midday air temperature above the canopy, moisture stress increases and crop yield declines. Application of the results is outlined.

SECTION XI

WATER SUPPLY AUGMENTATION AND CONSERVATION

SALINE WATER CONVERSION (GROUP 03A)

77:03A-001
AN ASSESSMENT OF IRRIGATION EFFICIENCIES AND DRAINAGE RETURN FLOWS FROM THE WELLTON-MOHAWK DIVISION OF THE GILA PROJECT,
Krull, D.L., and Clark, D.L.
United States Department of the Interior, Bureau of Reclamation, Yuma Projects Office, Yuma, Arizona.
Proceedings of National Conference on Irrigation Return Flow Quality Management, Colorado State University, Fort Collins, Colorado, p 335-348, May 16-19, 1977.
5 fig, 4 ref.

Descriptors: Desalination, Arizona, Irrigation efficiencies, Drainage, Return flows, Drainage water, Irrigation.

Public Law 93-320 authorized the construction of a large desalting plant to enable the United States to comply with its obligation under the agreement with Mexico of August 30, 1973 (Minute No. 242 of the International Boundary and Water Commission, United States and Mexico). The desalting plant will be constructed to treat the drainage waters from the Wellton-Mohawk Division of the Gila Project so these waters will be available for delivery to Mexico under the 1944 Mexican Water Treaty and Minute No. 242. By reducing the volume of drainage flows, the size of the desalting plant can be reduced. An interagency committee was established to determine and implement means of increasing irrigation efficiencies so as to reduce drainage return flows to the lowest practical volume and to identify an optimal economic solution relating desalting costs to specified irrigation efficiency levels. An assessment was made utilizing the water budget process to determine the relationship between increased irrigation efficiency levels and drainage return flows.

SECTION XII

WATER SUPPLY AUGMENTATION AND CONSERVATION

WATER YIELD IMPROVEMENT (GROUP 03B)

77:03B-001
AUGMENTING SUMMER STREAMFLOW BY USE OF A SILICONE ANTITRANSPIRANT,
Belt, G.H., King, J.G., and Haupt, H.F.,
Idaho University, College of Forestry, Wildlife and Range Sciences, Moscow, Idaho.
Water Resources Research, Vol. 13, No. 2, p 267-272, April 1977. 4 fig, 1 tab, 20 ref.

Descriptors: *Streamflow, *Transpiration control, *Idaho, Emulsions, Aqueous solutions, Transpiration, Soil water, Watersheds (basins), Regression analysis, Seasonal, Summer, Spraying.

A 65-acre (26.3-ha) cedar-hemlock catchment in northern Idaho was sprayed with a 5% aqueous emulsion of silicone soil to reduce transpiration. The antitranspirant, Dow Corning XEF-4-3561, was applied by helicopter at the rate of 40 gal/acre (375 l/ha). From June 1 to September 15, 1974, streamflow, soil water, and leaf water potential were monitored on the 65-acre (26.3 ha) treated watershed and on an adjacent 50-acre (20.2 ha) control watershed. By using the paired watershed method with regression equations based on 6 years of pretreatment data, predicted and observed streamflow were obtained for the period June 1 to September 15. Differences between predicted and observed streamflow were compared by using the paired "t" test and were found to be significant at the 97.5% confidence level. During a 63-day period, a 12% increase in streamflow resulted from the antitranspirant application. During the same period, soil water storage was greater on the treated watershed than on the control watershed; however, the difference was not statistically significant. Seasonal leaf water potential in cedar indicated that stress was greater on the control watershed than on the treated watershed. Systematic differences in leaf potential for hemlock did not occur.

SECTION XIII

WATER SUPPLY AUGMENTATION AND CONSERVATION

USE OF WATER OF IMPAIRED QUALITY (GROUP 03C)

77:03C-001
INFLUENCE OF SEED PRETREATMENTS ON SALT TOLERANCE OF COTTON DURING GERMINATION,
Channon, M.C., and Francois, L.E.
Agricultural Research Service, Salinity Laboratory, Riverside, California.
Agronomy Journal, Vol. 69, No. 4, p 619-622, July-August, 1977. 3 fig, 1 tab, 20 ref.

Descriptors: *Seed treatment, *Salt tolerance, *Germination, *Cotton, *Saline soils, Salinity, Arid lands, Salts, Sodium chloride, Saline water, Seeds, Irrigated land, Crop production, Irrigation water, Irrigation, Stress, Soil-water-plant relationships, Semiarid climates.

A study was conducted to determine if various seed pretreatments could increase the salt tolerance of a commercial variety of long-staple cotton (Gossypium barbadense L.). Salts, phytohormones, and adenosine monophosphate were used in twelve pretreatments (including a dry control and a distilled water control), and their effectiveness tested by germinating the seeds in single and mixed salts of NaCl and CaCl2, as well as distilled water. No evidence was found that pretreatment increases salt tolerance during germination. The beneficial effects seem limited to water pretreatment which hastened the germination of seed by one day over dry controls. A single four-hour soaking was optimal. This is hardly noteworthy under optimum field conditions, but under stress conditions it may be significant.

77:03C-002
OPTIMIZING CROP PRODUCTION THROUGH CONTROL OF WATER AND SALINITY LEVELS IN THE SOIL,
Stewart, J.I., Hagan, R.M., Hanks, R.J., Franklin, W.T., and Pruitt, W.O.
Utah Center for Water Resources Research, and Consortium for International Development, Logan, Utah.
Available from the National Technical Information Service, Springfield, Virginia 22161 as PB-275 466, Utah Water Research Laboratory, Logan, Utah. Publication PRWG151-1, September 1977, 191 p, 71 fig, 10 tab, 21 ref, 7 append.

Descriptors: *Optimization, *Crop production, *Soil water, *Salinity, *Irrigation, *Soil moisture, *Water management (applied), Saline water, Soil analysis, Plant growth, Moisture content, Root zone, Model studies.

The research was carried out by four universities belonging to the Consortium for International Development (CID) in cooperation with the four Water Research Centers. Similar field experiments with corn were carried out in 1974 and 1975 at the University of Arizona (Yuma Field Station), the University of California (Davis), Colorado State University (Fort Collins), and Utah State University (Logan). The objectives were to develop production functions for estimating how crop yield is influenced by different levels of salinity and water supply at different stages of crop growth, and to formulate and test models for predicting yields as a function of water and salinity stress across a broad spectrum of climate and soil types. A unique and significant feature of the study was the establishment of a sufficient data base to test the transferability of the results, and to accomplish this feature, the research was conducted on a regional basis with data collection at the four different locations. All irrigation was applied with a line source sprinkler system, developed in Utah, which gave a continuously variable amount of irrigation water on each side of the line. The maximum evapotranspiration (ET) was estimated at all locations and measured with lysimeters at California. Evapotranspiration (ET) was calculated at all plots as the sum of precipitation, irrigation, and soil water depletion minus drainage (estimated). Yields of dry matter and grain were measured at the end of each growing season. This study has provided an extensive data base on how corn yields respond to moisture deficiency and salinity stress under different soil and climatic conditions.

SECTION XIV

WATER SUPPLY AUGMENTATION AND CONSERVATION

CONSERVATION IN AGRICULTURE (GROUP 03F)

77:03F-001
METHOD FOR EVALUATING IRRIGATION PROJECTS,
Hogg, H.C., and Vieth, G.R.
Economic Research Service, Natural Resource Economics Division, Washington, D.C.
Journal of the Irrigation and Drainage Division, Proceedings of the American Society of Civil Engineers, Vol. 103, No. IR1, Proc. Paper No. 12828, p 43-52, March 1977. 2 fig, 3 tab, 9 ref.

Descriptors: *Irrigation, *Project feasibility, *Project planning, *Evaluation, *Crop production, *Return (monetary), *Methodology, Agriculture, Cost-benefit ratio, Evapotranspiration, Prices, Variability, Water distribution (policy), Optimization, Equations, Systems analysis, Mathematical models, Risks, Hawaii, Evaporation pans.

A methodology is presented for evaluating irrigation projects by comparing the performance of alternative system designs over a planning period specified by the user. The estimating model is based on a universal crop production function for water which is utilized to optimize interzonal water distribution. A solution is optimum if: (1) the value of product resulting from the last unit of water applied divided by the marginal cost of water (in this case the unit cost) is the same for all zones; (2) the value of product for the last unit of irrigation is not less than its cost; (3) there can be no negative irrigation levels, i.e., the interzonal transfer of rainfall; and (4) the total amount of irrigation water applied does not exceed the quantity available. Project zones are defined by climate, soil, and crop produced. Price and climatic uncertainty are dealt with directly in the model assuming the probability distribution of the respective variable is known. The measures of economic viability available for comparing alternative system designs include: the benefit/cost ratio, internal rate of return, and net present worth. Presented is an illustrative example--a single sugar plantation occupying multiple climatic zones and operating under conditions of price and climatic uncertainty.

77:03F-002
MINIMIZING CANAL CAPACITY FOR IRRIGATED RICE,
Hagan, R.E., and Wang, J-K.
Hawaii University, Department of Agricultural Engineering, Honolulu, Hawaii.
Journal of the Irrigation and Drainage Division, Proceedings of the American Society of Civil Engineers, Vol. 103, No. IR1, Proceedings Paper No. 12821, p 71-78, March 1977. 3 fig, 3 ref.

Descriptors: *Canal design, *Irrigation, *Rice, *Conveyance structures, Rotational flow, Efficiencies, Surface irrigation, Water demand, Equations, Systems analysis.

Improved formulas are developed for calculating the maximum canal or pump capacity needed for lowland rice rotational irrigation system design. The conventional and modified conventional formulas are derived from assumptions that cannot be satisfied during irrigation system operation. This induces water usage and management inefficiencies into the system. Analysis of the conventional and modified conventional formulas with the rotational irrigation system management practices isolates several criteria to be used in integrating design and operation. By this integration, irrigation system efficiency is increased. The maximum capacity given by the improved formulas is smaller than that required by the conventional and modified conventional formulas. This allows the use of smaller canals or an enlargement of the area, or both, serviced by a given water supply flow rate.

77:03F-003
IRRIGATION SYSTEM OPERATING POLICIES FOR MATURE TEA IN MALAWI,
Palmer-Jones, R.W.
Institute for Agricultural Research, Zaria (Nigeria).
Water Resources Research, Vol. 13, No. 1, p 1-7, February 1977. 2 fig, 3 tab, 15 ref.

Descriptors: *Irrigation systems, *Crop response, *Soil moisture, *Dynamic programming, Optimization, Effects, Rainfall, Equations, Mathematical models, Simulation analysis, Systems analysis, Water supply, Operations.

The technical specification of plant-water relationships has led to errors in the formulation of response models for water inputs. Consequently, the optimizing procedures making use of these models may have been misleading as to both the practical water application rules recommended and the usefulness of the optimizing procedure. In this paper, it is shown that the distribution of water within the root zone, specifically for tea in Malawi, plays an important part in determining response to irrigation. This means that two or more soil moisture state variables will be necessary in the dynamic programming (DP) method of finding the optimal application policy, and this makes DP even more difficult to use in practice than has been previously indicated. It is shown that response to irrigation depends on the amount of water in the uppermost layer of the soil and that the effect of an irrigation on yield is through its effect on the current level of this variable and on its future levels through the effect of current irrigation on the water contents of lower layers of the soil. Optimal applications are found to be determined by two variables: the water content of the uppermost layer (30 cm) and the water content of the remainder of the root zone. The optimal system distribution policy capacity is found to be close to the level that would just replace the maximum deficit that could build up in the uppermost layer between irrigation rounds.

77:03F-004
TRICKLE IRRIGATION AND FERTILIZATION OF TOMATOES IN SAND DUNES: WATER, N, AND P DISTRIBUTIONS IN THE SOIL AND UPTAKE BY PLANTS,
Bar-Yosef, B.
Agricultural Research Organization, Division of Soil Chemistry and Plant Nutrition, Bet Dagan (Israel).
Agronomy Journal, Vol. 69, No. 3, p 486-491, May-June, 1977. 1 fig, 11 tab, 8 ref.

Descriptors: *Irrigation effects, *Fertilization, *Tomatoes, *Dune sands, *Nutrient requirements, Moisture uptake, Soil-water-plant relationships, Crop production, Crop response, Nitrogen, Irrigation practices, Soil water, Water utilization, Root zone, Leaching, Phosphorus.

Various daily rates of water, N, and P were applied through a trickle irrigation system to tomato plants (Lycoperisicum esculentum Mill.) grown on coastal dunes of fine sand in southern Israel. Fruit yields were greatest (about 110 tons/ha) when the daily average water content in the soil root volume was around 5%(w/w), N concentration in the soil solution 140 + or -40 ppm N, and N uptake rate about 100 mg N/plant/day. Daily water consumption varied from 0.4 to 1.0 liter/plant/day, depending on leaf area and climatic conditions. In general, water use efficiency decreased with time. The amount of water used to produce 1 g dry matter was similar in all treatments (about 250 + or -40 g water/g d.m.). Plants absorbed 30 to 50% of the added N, this low recovery probably due to leaching losses.

77:03F-005
A NEW APPROACH FOR ESTIMATING IRRIGATION CONVEYANCE LOSSES AND THEIR ECONOMIC EVALUATION,
Palacios, E.V., and Day, J.C.
Escuela Nacional de Agricultura, Colegio de Postgraduados, Chapingo (Mexico).
Water Resources Bulletin, Vol. 13, No. 4, p 709-719, August 1977. 1 tab, 2 fig, 5 ref.

Descriptors: *Irrigation systems, *Canals, *Economic feasibility, Methodology, Irrigation districts, Mexico, Statistical methods, Water management (applied), Networks, Flow, Costs, Benefits, Estimating, Evaluation, Water supply, Water delivery, Regression analysis, Equations, Mathematical models, Systems analysis.

A new methodology for estimating conveyance efficiency within irrigation systems is presented. Based on statistical analysis of daily water releases from the source of supply and deliveries to the farmers in an irrigation district in Mexico, a linear model is obtained for estimating conveyance efficiency and two component factors. One of these factors points out the relative importance of the operational losses (for example, losses due to water management), and the other shows the importance of the fixed losses which can be attributed to the average flow through the canal network without variations. Next, an analysis of the expected benefits and costs accruing from system improvement permits derivation of a decision rule which may be used in analyzing the economic feasibility of lining in-place canals. Results show that conveyance efficiency may be significantly increased by improving the operating rules in an irrigation system, this being the cheapest way of attaining the improvement. However, since many variable factors may affect the economic feasibility of lining canals, careful studies should be made regarding infiltration rate measurements, cost of lining, days of effective operation per year of each canal, etc., before making decisions regarding the lining of the canal in question.

77:03F-006

REGULATION OF GRAIN YIELD BY PHOTOSYNTHESIS IN MAIZE SUBJECTED TO A WATER DEFICIENCY,

McPherson, H.G., and Boyer, J.S.
Department of Scientific and Industrial Research, Plant Physiology Division, Palmerston North (New Zealand).
Agronomy Journal, Vol. 69, No. 4, p 714-718, July-August, 1977. 6 fig, 1 tab, 30 ref.

Descriptors: *Photosynthesis, *Moisture deficit, *Crop production, *Translocation, Corn (field), Crop response, Grains (crops), Moisture uptake, Plant physiology, Droughts, Plant growth.

Drought causes massive losses in the yield of crops, but the physiological mechanisms responsible for decreased yields are poorly understood. Experiments were conducted on maize plants to attempt to identify these mechanisms. The plants were subjected to a water deficiency during most of the grain filling period. They were grown in a controlled environment capable of providing yields comparable to the field. Grain yields, dry weights of shoots and roots, apparent photosynthesis, and leaf water potential were determined. The results are presented. At low leaf water potentials, the grain developed partly at the expense of photosynthesis accumulated prior to the desiccation period. Since grain development is dependent entirely on translocation in maize, this indicated that translocation continued despite the cessation of apparent photosynthesis. Translocation is less inhibited than photosynthesis accumulation for the growing season controls yield during a drought.

77:03F-007

THE ROLE OF EPA'S OFFICE OF RESEARCH AND DEVELOPMENT IN IRRIGATED CROP PRODUCTION RESEARCH,

Law, J.P., Jr., and Hornsby, A.G.
United States Environmental Protection Agency, Environmental Research Laboratory, Office of Research and Development, Ada, Oklahoma.
Proceedings of National Conference on Irrigation Return Flow Quality Management, Colorado State University, Fort Collins, Colorado, p 1-6, May 16-19, 1977. 1 fig.

Descriptors: Water quality control, Water pollution, Irrigation, Irrigated land, Water management (applied), Return flow, Research and development, Agricultural activities, Wastewater management.

In setting the stage for the conference, the role of the Irrigated Crop Production research program will be described. The legislative mandates of PL 92-500 to EPA will be reviewed in relation to the charge to control water quality degradation resulting from agricultural activities. The overall objectives of the program, established prior to the passage of PL 92-500, appear to be valid and supportive of the efforts of the program thus far. This conference represents a compendium of the results of the program's efforts as well as a hard look at the future direction the program should take. Supported research has included technology development and evaluation of its effectiveness in water pollution abatement and/or control. The technology investigated has included both structural and nonstructural improvements within the water delivery, farm, and water removal subsystems of irrigated agriculture. Additional studies have investigated the legal, socio-economic, and/or other institutional constraints to water management reform. More effort will be required in these areas. Current program emphasis is evolving into a phase which we are referring to as implementation research. Included in this is the preparation of research-based guidance documents aimed at providing much needed information for those state agencies responsible for planning and implementing areawide wastewater management alternatives involving nonpoint source agricultural activities. The discussions of this conference should provide great impetus toward that goal.

77:03F-008
SCIENTIFIC IRRIGATION SCHEDULING FOR SALINITY CONTROL OF IRRIGATION RETURN FLOW,
Jensen, M.E.
United States Department of Agriculture, Snake River Conservation Research Center, Kimberly, Idaho.
Proceedings of National Conference on Irrigation Return Flow Quality Management, Colorado State University, Fort Collins, Colorado, p 133-139, May 16-19, 1977. 3 tab, 6 ref.

Descriptors: Model studies, Irrigation water, Leaching, Return flow, Irrigation efficiency, Evapotranspiration.

Basic principles of irrigation water management and irrigation scheduling are presented. Commercial and agency groups expanded rapidly in the 1970's providing field-by-field scheduling services to over 600,000 acres in 1976. The leaching fraction used on projects can effect return flow quality. Most leaching fraction return flow models hypothetically assume uniform water applications of exact quantities to attain targeted leaching fractions. The average or effective leaching fraction for a field is dependent on the irrigation uniformity coefficient. The effects of nonuniform water application on average leaching fractions will be presented, along with the probable effects of expected improvements in irrigation efficiency on return flow. Also, estimates of the accuracies in estimating evapotranspiration and measuring water will be presented. Substantial improvements can be made in irrigation efficiencies before minimum leaching fractions are reached on most western irrigated projects.

77:03F-009
DRIP/TRICKLE IRRIGATION GENERATING GROWTH, OPTIMISM,
Ross, R.
Irrigation Age, Vol. 11, No. 3, p 14-16, November-December, 1976. 1 fig.

Descriptors: *Irrigation practices, Irrigation, Irrigation systems, Water conservation, Irrigation efficiency.

Irrigation Age, in a series of personal interviews during the International Drip Irrigation Association meeting, spoke to several representatives of various drip/trickle industry segments.

77:03F-010
WATER MOVEMENT IN BARE AND CROPPED SOIL UNDER ISOLATED TRICKLE EMITTERS: I. ANALYSIS OF BARE SOIL EXPERIMENTS,
Jury, W.A., and Earl, K.D.
California University, Department of Soil Science and Agricultural Engineering, Riverside, California 92502.
Soil Science Society of America Journal, Vol. 41, No. 5, p 852-856, September-October, 1977. 8 fig, 1 tab, 12 ref.

Descriptors: Hydraulic conductivity, Soil water, Soil water movement, Tensiometers, Sampling, Irrigation, Irrigation effects, Irrigation practices, Irrigation systems.

A field experiment on a Buren sandy loam with a low (0.5 centimeters per hour) saturated hydraulic conductivity is reported in which water movement in soil irrigated from a single isolated trickle emitter was observed. Water was introduced at a uniform rate of 4 liters per hour and a weekly volume of 84 liters at frequencies of 3 irrigations per day and 1 irrigation per week. During a 41-day experiment, soil water movement was followed by tensiometers and gravimetric water content sampling, and surface ponding was recorded by photography. It was found that more water moved laterally in the weekly irrigation plots than in the daily ones, a result which was not consistent with predictions of simplified theoretical models which did not consider surface ponding. Observation of the wetted radius at the surface indicated that substantial amounts of water were running off laterally during the weekly irrigation, which could account for the storage changes seen at large radial distances from the emitter.

77:03F-011
WATER MOVEMENT IN BARE AND CROPPED SOIL UNDER ISOLATED TRICKLE EMITTERS: II. ANALYSIS OF CROPPED SOIL EXPERIMENTS,
Earl, K.D., and Jury, W.A.
California University, Department of Soil Science and Agricultural Engineering, Riverside, California 92502.
Soil Science Society of America Journal, Vol. 41, No. 5, p 856-861, September-October, 1977. 6 fig, 4 tab, 21 ref.

Descriptors: Hydraulic conductivity, Soil water, Soil water movement, Tensiometers, Sampling, Irrigation, Irrigation effects, Irrigation practices, Irrigation systems, Root systems, Crop response, Evapotranspiration.

Soil moisture and plant root distributions were evaluated when plots of summer squash were trickle irrigated with two contrasting frequencies of water application. Replicated plots receiving the same total volumes of water were irrigated three times daily and once weekly, with irrigation volumes adjusted according to evapotranspiration and tensiometric data. In the presence of actively growing zucchini, weekly irrigations produced a greater movement of water both laterally and vertically downward than daily irrigations. Plant roots were distributed according to the wetted volume of soil, with roots of weekly irrigated plots being more evenly distributed than in daily irrigated plots where roots were concentrated beneath the emitter. The imposition of a water stress demonstrated a marked increase in root density beneath the emitters as a result of proliferation of fine root material. Zucchini yields in the outer ring of weekly irrigated plants (100 centimeters from emitter radially) were 30 percent higher than the most productive daily irrigated plot. Furthermore, total green matter and dry matter yields were greater in weekly irrigated plots.

77:03F-012
THE PRODUCTION OF PHYTOTOXINS FROM SURFACE CROP RESIDUES,
Cochran, V.L., Elliott, L.F., and Papendick, R.I.
United States Department of Agriculture, Agricultural Research Service, Western Region, Pullman, Washington 99164.
Soil Science Society of America Journal, Vol. 41, No. 5, p 903-908, September-October, 1977. 6 fig, 1 tab, 20 ref.

Descriptors: Crop production, Crop response, Washington, Micro organisms, Bluegrasses, Soils, Soil investigations, Organic matter.

Experiments were conducted to determine if crop residues, common to eastern Washington, were likely to cause phytotoxicity problems with no-till planting of winter wheat. The possible role of microorganisms was assessed also. Mats of pea, wheat, barley, and bluegrass residues were spread over bare soil in September of 1975. Water extracts of the residues and soil beneath them were bioassayed weekly for wheat-seedling phytotoxins and the residues were plated biweekly to determine the numbers of fungi, bacteria, and pseudomonads from September of 1975 through May 1976. All residues produced wheat-seedling root inhibitors, but only after conditions became favorable for microbial growth.

77· 03F-013
THE BIOLOGY AND MODELLING OF FERTILIZER RESPONSE,
Helyar, K.R., and Godden, D.P.
New South Wales Department of Agriculture, Agricultural Research Centre, Department of Agronomy, Wollongbar, N.S.W., 2480.
Journal of the Australian Institute of Agricultural Science, Vol. 43, No. 1 & 2, p 22-30, March-June, 1977. 7 fig, 17 ref, 16 equ, 1 append.

Descriptors: Nutrients, Fertilizers, Fertilization, Soil investigations, Crop response, Crop production, Model studies.

A theory has been presented which can be used to account for the native soil nutrient status, residual effects of past fertilizer applications and the effect of current fertilizer application on plant yield. The procedure enables the partitioning of fertilizer between inputs required to balance losses and inputs required to build up soil nutrient reserves. Because of this feature, a logical basis for the economic analysis of fertilizer response and for understanding the practical significance of observable responses is provided.

77:03F-014
NITROGEN RESPONSES OF TALL FESCUE AND RYEGRASS SURVIVOR POPULATIONS FROM A RATE-OF-NITROGEN EXPERIMENT,
Harris, W., and Lazenby, A.
New England University, Department of Agronomy and Soil Science, Armidale, New South Wales 2351, Australia.
New Zealand Journal of Agricultural Research, Vol. 20, No. 3, p 327-330, August 1977. 2 tab, 8 ref.

Descriptors: Nitrogen, Fertilizers, Fertilization, Nutrients, Crop production, Crop response, Grasses.

Survivor populations of ryegrass and tall fescue from an experiment in which nitrogen was applied at rates of 0 to 1344 kg/ha/year were tested for nitrogen response in the range from 0 to 4352 kg N/ha in a single application. Applications above 544 kg N were supra-optimal and were totally toxic at 4352 kg N. There were no indications of adaptation of the different survivor populations to either sub-optimal or supra-optimal levels of nitrogen.

77:03F-015
ISOTOPIC STUDIES ON THE UPTAKE OF SULPHUR BY PASTURE PLANTS, I. A METHOD FOR THE DIRECT INTRODUCTION OF 35S ISOTOPE INTO THE SOIL PROFILE UNDER FIELD CONDITIONS,
Goh, K.M., Gregg, P.E.H., Brash, D.W., and Walker, T.W.
Lincoln College, Department of Soil Science, Canterbury, New Zealand.
New Zealand Journal of Agricultural Research, Vol. 20, No. 2, p 221-227, May 1977. 6 fig, 3 tab, 22 ref.

Descriptors: Isotope studies, Sulphur, Soil investigations, Soil profiles, Pastures, Pasture management, Root systems, Soil chemistry, Soil chemical properties.

A method for the direct introduction of 35S isotope into different soil depths under field conditions to study the uptake of sulphur by pasture plants is described. This method was designed to minimize bias and contamination during the introduction of the isotope. It involved the horizontal introduction of the isotope enclosed in water-soluble capsules. Recovery of 35S by the pasture plants indicated that when 35S was introduced at a depth of 22 centimeters the area above ground in which pasture plants were labeled extended little more than 15 centimeters from the line of placement. This lateral spread of 35S in the pasture plants varied according to the soil and the depth of application. The results may be explained in terms of the extent and nature of root development in the soil profile.

77:03F-016
ISOTOPIC STUDIES ON THE UPTAKE OF SULPHUR BY PASTURE PLANTS, II. UPTAKE FROM VARIOUS SOIL DEPTHS AT SEVERAL FIELD SITES,
Gregg, P.E.H., Goh, K.M., and Brash, D.W.
Ministry of Agriculture and Fisheries, Research Division, Christchurch, New Zealand.
New Zealand Journal of Agricultural Research, Vol. 20, No. 2, p 229-233, May 1977. 5 tab, 10 ref.

Descriptors: Isotope studies, Sulphur, Soil investigations, Soil profiles, Pastures, Pasture management, Root systems, Soil chemistry, Soil chemical properties.

On two contrasting soils, Kowai sandy loam (recent soil) and Gorge silt loam (lowland yellow-brown earth) in inland Canterbury, New Zealand, plant uptake of 35S-sulphur placed at various soil depths and also the uptake of associated soil sulphur (32S) present at the same depths were investigated in developed pastures under field conditions. Results from the first harvest in the spring of 1972 showed that on both soils white clover and perennial ryegrass plants used sulphur from all four depths studied (for example, 7.5, 22.5, 37.5, and 52.5 cm).

77:03F-017
POLICY ALTERNATIVES FOR THE PRESERVATION OF AGRICULTURAL LAND USE,
Lapping, M.B.
Vermont University, Environmental Program and School of Natural Resources,
Burlington, Vermont 05401.
Journal of Environmental Management, Vol. 5, No. 3, p 275-287, July 1977. 3 tab, 31 ref.

Descriptors: Agriculture, Land use, Land resources, Land development, Land classification, Land, Rural area.

Increasing demands for food and fiber are making the retention and preservation of prime agricultural land a focus of contemporary land policy. This is a particular problem in the United States and other industrialized nations where pressures to convert agricultural land to other uses are strong and sustained. Various measures and strategies to maintain farmland are examined and critiqued. The paper concludes with the recommendation that the state or provincial level of administration can be most effective in the preservation process, and that a wide array of programs and strategies is essential to meet local environmental differences.

77:03F-018
WATER SHORTAGE IN ISRAEL: LONG-RUN POLICY FOR THE FARM SECTOR,
Gisser, M., and Pohoryles, S.
New Mexico University, Department of Economics, Albuquerque, New Mexico.
Water Resources Research, Vol. 13, No. 6, p 865-872, December 1977. 1 fig, 5 tab, 4 ref.

Descriptors: *Water shortage, *Income, *Linear programming, *Estimating, *Water allocation (policy), Agriculture, Water supply, Data, Technology, Economic efficiency, Constraints, Regions, Mathematical models, Systems analysis.

In the year 1985, it is expected that Israel will suffer a significant deficit in its water balance; this country faces a situation of limited water supply and increasing demands. Since agriculture uses a large fraction of the available water, one potential policy is to reduce allocations of water to agriculture in order to permit the growth of its use in other sectors. A linear programming model is used to estimate the total loss in income to agriculture from reduction in current allocations; these estimates are to be taken as guideline estimates only. Results show that a 10%, 20%, or 30% reduction in water quotas will give rise to roughly a 6%, 12%, or 18% reduction in farm income if no technological change is assumed. If technological changes are supposed, then the reductions in agricultural income will be 1%, 7%, and 12%, respectively. Policy recommendations are given: (1) use the extension services to help farmers in the moshavim to switch from the moshav dairy farm to a large-scale water-efficient kibbutz-type farm; (2) provide the loans that would be needed for the above transformation; (3) to enhance intrasector efficiency, encourage farmers to trade in water quotas on the margin, and this would work only if the practice were to (4) charge the real marginal cost on the margin (the margin should cover 15%-21%).

77:03F-019
WATER TABLE DEPTH AND IRRIGATION EFFECTS ON WATER USE EFFICIENCIES OF THREE CROPS,
Benz, L.C., Reichman, G.A., Doering, E.J., and Follett, R.F.

United States Department of Agriculture, Agricultural Research Service, Northern Great Plains Research Center, Mandan, North Dakota.
Presented at the 1977 Annual Meeting of the American Society of Agricultural Engineers, June 26-29, 1977, Raleigh, North Carolina, North Carolina State University, p 1-17. 7 fig, 3 tab, 14 ref.

Descriptors: Irrigation, Irrigation efficiency, Corn, Sugar beets, Water table, Irrigation effects, Irrigation practices, Alfalfa.

Production and applied water-use efficiencies (AWUE) of corn, sugar beets, and alfalfa from a 3-year field experiment at three water table depths and four irrigation rates were highest from the shallow water table treatment without irrigation, regardless of irrigation treatment.

77:03F-020
LIMITED TILLAGE SAVES SOIL, WATER, AND ENERGY,
Allen, R.R., and Fryrear, D.W.
United States Department of Agriculture, Southwestern Great Plains Research Center, Bushland, Texas.
Presented at the 1977 Annual Meeting, American Society of Agricultural Engineers, June 26-29, 1977, Raleigh, North Carolina, North Carolina State University, p 1-14. 6 tab, 22 ref.

Descriptors: Herbicides, Soil conservation, Erosion, Runoff, Soil moisture, Soil water, Agriculture, Mulching, Nebraska, Crop production.

Limited and high cost energy since 1973 has added to the pressures upon agricultural production. This paper discusses how limited tillage can conserve energy as well as soil and water on the Great Plains. Stubble-mulch tillage, which began on the Great Plains for wind erosion control, was the forerunner of present limited tillage systems. Stubble-mulch reduced annual wind erosion from 6.5 to 2.0 metric tons/ha in western Nebraska and increased wheat production by 13 percent at Bushland, Texas, while using equal or less energy than clean tillage. Use of herbicides, or herbicides plus sweep tillage on fallow, increased soil water storage and reduced energy use in Kansas, Nebraska, and Texas. On sandy soils of the Southern Great Plains, crops such as cotton may not leave enough residue to prevent soil blowing. This may require additional energy to spread a mulch such as cotton gin trash or perform emergency surface-roughening tillage. With deep well irrigation of crops, energy for tillage is overshadowed by energy to pump water and manufacture fertilizer. Pumping and fertilizer energy can be 10 to 25 times higher than for tillage.

77:03F-021
PULSE IRRIGATION--DESIGN FOR OPERATING SETS,
Karmeli, D., and Peri, G.
Colorado State University, Department of Agricultural Engineering, Fort Collins, Colorado.
Journal of the Irrigation and Drainage Division, Proceedings of the American Society of Civil Engineers, Vol. 103, No. IR1, p 33-41, March 1977. 1 fig, 3 tab, 1 ref.

Descriptors: *Irrigation efficiency, *Pumping, *Design, *Operations, Irrigation practices, Discharge (water), Equations, Irrigation systems.

A process of design for operating sets with pulse irrigation has been developed. The process allows for an efficient operation and also adjusts the operating sets to the characteristics of the pulse as formulated in a previous work. The adjustment expresses itself mainly in the establishment of the number of stations operating with one pulsator and in the various parameters of the pulse. The process allows for the design of a number of sets and stations when the total duration of irrigation and total number of valves in the field are given. The number of sets and stations per set must be established so as to have identical numbers of stations per set. The characteristics of the remaining stations will be different as the number is smaller and the duration time of operation is maximal.

77:03F-022

EFFICIENT AND INEFFICIENT USE OF PHOSPHORUS BY SORGHUM,

Brown, J.C., Clark, R.B., and Jones, W.E.
United States Department of Agriculture, Agricultural Research Service, Plant Stress Laboratory, Beltsville, Maryland 20705.
Soil Science Society of America Journal, Vol. 41, p 747-750, July-August, 1977. 3 fig, 5 tab, 22 ref.

Descriptors: Phosphorus, Sorghum, Nutrients, Soils, Crop response, Fertilizers.

Twelve genotypes were grown on acid-Bladen soil (pH 4.3, P stressed or Al toxic), on limed-Bladen soil (pH 5.2, Cu stressed), and on alkaline Quinlan soil (pH 7.5, Fe stressed) to determine the effect of P efficiency on use of these elements by the plants. Under P-stress or Al-toxicity conditions, the most P-efficient sorghum genotypes absorbed more 32P than the most P-inefficient lines and grew normally, while the P-inefficient plants developed P deficiency symptoms. Under Fe-stress conditions, the most P-efficient genotypes developed Fe chlorosis, while the most P inefficient plants remained green. Under Cu-stress conditions, one of six genotypes developed severe Cu-deficiency symptoms, characterized by the accumulation of higher P in the lower leaves, and by lower Fe and Ca in upper leaves of Cu-stressed plants as compared with Cu-sufficient plants. Thus, P efficiency in plants may be an asset when P availability limits growth, but it may be a liability when these same plants are subjected to Fe or Cu stress.

77:03F-023

EFFECT OF IRRIGATION SYSTEMS ON THE WATER REQUIREMENTS OF SWEET CORN,

Wendt, C.W., Onken, A.B., Wilke, O.C., Hargrove, R., and Bausch, W.
Texas A and M University Agricultural Research and Extension Center, Texas Agricultural Experiment Station, Lubbock, Texas.
Soil Science Society of America Journal, Vol. 41, No. 4, p 785-788, July-August, 1977. 3 fig, 2 tab, 14 ref.

Descriptors: Irrigation, Irrigation systems, Sprinkler irrigation, Furrow irrigation, Subsurface irrigation, Corn, Evapotranspiration, Tensiometers, Soil moisture.

A field study was conducted to determine the influence of sprinkler irrigation (Sp), furrow irrigation (F), subirrigation (Su), and automated subirrigation (ASu) on the water requirements of sweet corn. Irrigation water was applied to the Sp, F, and Su plots when the soil water potential at the 30-cm depth in the row reached -40 cbars potential. The time and amount of water applied was based on a combination of leaf area index (LAI) and potential evapotranspiration (ET(p)). Water application to the ASu plots was controlled by a switching tensiometer 30 cm deep set at -40 cbars potential. Soil water content changes were determined by gravimetrically sampling the surface 15 cm and obtaining neutron probe measurements of water in the deeper depths. Significant differences existed in the irrigation water requirement of the sweet corn irrigated by the different systems (F = 351 mm, SP = 248 mm, Su = 248 mm, ASu = 142 mm). However, little difference in consumptive use occurred between systems (F = 361 mm, Sp = 346 mm, Su = 346 mm, ASu = 310 mm) due to differences in soil water utilization. Automation of irrigation systems offers the possibility of significantly enhancing irrigation water use efficiency in supplementally irrigated areas.

77:03F-024

MANAGING FARMLAND TO IMPROVE WATER QUALITY,

Morrison, J.
Purdue University, Department of Agricultural Information, West Lafayette, Indiana 47907.
Journal of Soil and Water Conservation, Vol. 32, No. 5, p 205-208, September-October, 1977. 3 fig.

Descriptors: Indiana, Erosion, Runoff, Water quality, Water quality control, Watersheds (basins), Agriculture.

For five years a 12,000-acre watershed in the rich agricultural land of Indiana's Maumee Basin has been under intensive study by researchers representing a variety of disciplines and interests. The project was named after Black Creek, the area's major drainageway. Investigations have touched on complex management, policy, and scientific issues, but the fundamental questions are relatively simple. 1. What is the relationship between erosion in the Black Creek watershed and water quality in Black Creek, the Maumee River, and Lake Erie? 2. Can a program based on voluntary participation by landowners, encouraged by cost-sharing incentives, have much impact on either erosion or water quality?

77:03F-025
REGULATORY PROGRAMS FOR NONPOINT POLLUTION CONTROL: THE ROLE OF CONSERVATION DISTRICTS,
Garner, M.M.
National Association of Conservation Districts, 1025 Vermont Avenue, N.W., Washington, D.C. 20005.
Journal of Soil and Water Conservation, Vol. 32, No. 5, p 199-204, September-October, 1977. 4 fig, 32 ref.

Descriptors: Water quality, Water quality management, Water pollution, Water pollution control, Water conservation.

Conservation districts are in a unique position to play a major role in state and areawide water quality management plans developed under Section 208 of the Federal Water Pollution Control Act Amendments of 1972 (Public Law 92-500). These districts, which in most states are local subdivisions of state government, number about 3,000. They encompass virtually all the privately owned land in the nation, including both rural and urban areas.

77:03F-026
CRITERIA AND STRATEGIES FOR MAINTAINING AGRICULTURE AT THE LOCAL LEVEL,
Derr, D., Small, L., and Dhillon, P.
Rutgers University, Cook College, Department of Agricultural Economics and Marketing, New Brunswick, New Jersey 08903.
Journal of Soil and Water Conservation, Vol. 32, No. 3, p 118-122, May-June, 1977. 3 fig, 13 ref.

Descriptors: Agriculture, Land use, Land development, Crop production, Urbanization.

Until recently, agricultural land was regarded as a reserve from which land needed for other uses could be drawn with little regard for the impact on the productivity of the remaining area. But the continued decline of agriculture near urban areas has precipitated concern among people both in and out of agriculture.

77:03F-027
TECHNOLOGY DEVELOPMENT AND TRANSFER FOR NATURAL RESOURCES MANAGEMENT,
Saxton, K.E.
United States Department of Agriculture, Agricultural Research Service, Pullman, Washington.
Journal of Soil and Water Conservation, Vol. 32, No. 3, p 123-125, May-June, 1977. 1 fig, 9 ref.

Descriptors: Technology, Natural resources, Agriculture, Economics, Environmental control.

Conservationists, engineers, and planners are experts in applying technology to achieve efficient natural resource use and safe, dependable structures. The technology they use represents years of experience and research. But as these professionals know, current technology must be refined or replaced with improved concepts and procedures if we are to achieve and maintain a cleaner environment, economical farming with sustained high yields, and effective conservation practices.

77:03F-028
DRIP SYSTEM EVALUATION,
Davids, G.
Harza Agricultural Services, Department of Agricultural Engineering.
Drip/Trickle Irrigation, Vol. 2, No. 2, p 20-21, March-April, 1977.

Descriptors: Irrigation systems, Irrigation efficiency, Irrigation practices, Uniformity, Uniformity coefficient, Soil moisture.

In maintaining a soil moisture budget for any irrigation unit, one of the essential pieces of input data is the net irrigation amount. When an irrigator operates his system, it is essential to determine the net or effective irrigation depth applied as accurately as possible. All drip/trickle systems should have metering devices to measure flow volume or rates, so the gross irrigation amount is easily verified.

77:03F-029
INSTALLATION OF DRIP IRRIGATION FOR ROW CROPS,
Chapin, R.
Chapin Watermatics, Post Office Box 298, Watertown, New York 13601.
Drip/Trickle Irrigation, Vol. 2, No. 2, p 9-11, March-April, 1977. 6 fig.

Descriptors: Irrigation systems, Irrigation practices, Crop production, Subsurface irrigation, Field crops, Irrigation design.

The installation of drip irrigation for row crops differs somewhat from that of orchards for three reasons. First, the rows are closer together and consequently require many more drip lines per acre. Second, with row crops much of the equipment is moved out of the field between crops; however, in orchards, it remains in the field permanently. Third, usually the submains are buried, and the drip lines themselves may either be buried, or on the surface. On a typical installation, row length may be 1,200 feet or more.

77:03F-030
MINIMUM SCREENING AND AUTOMATIC FLUSHING,
Shearer, M.N.
Oregon State University, Department of Extension Irrigation, Corvallis, Oregon.
Drip/Trickle Irrigation, Vol. 2, No. 2, p 14-16, March-April, 1977. 5 fig, 1 tab.

Descriptors: Filtration, Irrigation systems, Irrigation practices, Irrigation water, Organic matter, Suspended solids, Surface water, Automation.

We previously reported the success Dr. Mellenthin had at the Hood River Experiment Station in avoiding emitter plugging by using a self-cleaning, 200 mesh screen and weekly flushing of laterals by hand. Although organic matter was present in the ditch water, only 1 1/2% of the solid material flushed from the laterals was organic. This year a variety of emitters were again used at the station with no apparent plugging problems, except for microtube emitters, which exhibited varying degrees of flow reduction. However, labor to flush the individual laterals was still a problem.

77:03F-031
ASSESSING PHOSPHORUS FERTILIZER NEEDS BASED ON INTENSITY-CAPACITY RELATIONSHIPS,
Lee, Y.S., and Bartlett, R.J.
Vermont University, Department of Plant and Soil Science, Burlington, Vermont 05401.
Soil Science Society of America Journal, Vol. 41, No. 4, p 710-712, July-August, 1977. 4 fig, 12 ref.

Descriptors: Phosphorus, Fertilizers, Fertilization, Soils, Soil investigations, Crop response, Nutrients.

Phosphorus in a pH 4.8 NH40Ac soil extract, through crop response correlation work, may indicate the degree to which a level of P in a given soil is optimum. But, being an intensity measurement, this NH40Ac-P value does not indicate the amount of P fertilizer needed to bring a soil, which has a particular P sorption capacity, to its optimum level. The relationship between added P and the square root of the NH4OAc-P, measured after incubation of a given acid or limed soil, was a straight line with a characteristic slope for that soil. The value of this slope, termed the Phosphorus Fertilizer Index (PFI), showed a high correlation with the amount of Al extracted by pH 4.8 NH4OAc (sq r = 0.94). Inclusion of soil chemical characteristics other than Al in the calculation did not improve the P intensity-capacity relationships significantly.

77:03F-032
AMMONIUM EFFECTS ON NUTRIENT CATION ABSORPTION BY WHEAT,
Cox, W.J., and Reisenauer, H.M.
Department of Agriculture, South Perth, Western Australia 6151.
Agronomy Journal, Vol. 69, No. 5, p 868-871, September-October, 1977. 1 fig, 3 tab, 18 ref.

Descriptors: Nutrients, Fertilizers, Fertilization, Cations, Absorption, Wheat, Nitrogen, Potassium, Calcium, Zinc, Magnesium, Manganese.

Additions of small amounts of NH4 to adequate (-)NO3 culture have been shown to increase crop yield and total N content, and to decrease the plant's content of metal cations. The magnitudes of these effects can be appreciable. Accordingly, experiments were done to elucidate their mechanisms, and to evaluate their roles in crop production. Wheat was grown in the greenhouse in dilute constant-composition cultures that supplied, in factorial combination, three levels of NH4 with four levels of either K, Ca, Mg, Mn, or Zn. Intake of mineral cations increased with the concentration of the ion in solution and was decreased by added NH4.

77:03F-033
SUGAR CANE GROWTH IN RESPONSE TO MULCH AND FERTILIZER ON SALINE-ALKALI SUBSOILS,
Eavis, B.W., and Cumberbatch, E.R.St.J.
Ministry of Overseas Development, Department of Soil Physics, United Kingdom.
Agronomy Journal, Vol. 69, No. 5, p 839-842, September-October, 1977. 2 fig, 2 tab, 8 ref.

Descriptors: Mulches, Sugar cane, Crop response, Crop production, Fertilizers, Fertilization, Nutrients, Salinity, Subsoils, Leaching, Land reclamation.

In many parts of the world where salinity or alkalinity limit crop yields, leaching is impracticable. In Barbados saline-alkali subsoils remained unproductive six years after they were exposed during earth-moving operations. The objective of this study was to devise agronomic techniques to restore these lands to sugar cane production. The effects of mulching and N-K fertilization were studied. Factorial field experiments in which bare plots and plots mulched with cut grass were treated with fertilizer at three rates were carried out at two locations (sandy clay and clay soil, respectively). Sugar cane tillers and soil moisture contents were measured weekly, and root development fortnightly. After 9 months of growth, bare plots failed to produce any marketable yield in contrast to mulched plots which gave up to 53 metric tons/ha (sandy clay) and 118 tons/ha (clay). There were no responses to fertilizer rate on bare land, but on mulched land 1.2 times (sandy clay) and 2.2 times (clay) more yield resulted from the high compared with the low fertilizer rate.

77:03F-034
GROWTH AND YIELD OF SPRING WHEAT AS INFLUENCED BY SHELTER AND SOIL WATER,
Frank, A.B., Harris, D.G., and Willis, W.O.
Northern Great Plains Research Center, Department of Plant Science, Mandan, North Dakota 58554.
Agronomy Journal, Vol. 69, No. 6, p 903-906, November-December, 1977. 1 fig, 6 tab, 20 ref.

Descriptors: Windbreaks, Wheat, Irrigation, Irrigation effects, Crop production, Crop response, Soil water, Wind velocity, Leaves.

In the Northern Great Plains, windbreaks have historically been used to protect crops and soils from winds, but data on the effects of windbreaks on growth and yield of small grains is limited. "Waldron" wheat was grown on Parshall fine sandy loam with and without shelter (slat-fence enclosures), both with and without irrigation, to determine the effects of soil water and shelter on wheat growth and yield. In 1973 and 1974, plant height, tiller production, leaf area index, specific leaf weight, and dry matter were measured at tillering, heading, and grain-filling growth stages. Also, grain yield, kernel weight, number of heads, straw yield, and plant height were measured at crop maturity.

77:03F-035
PLANT WATER RELATIONSHIPS OF SPRING WHEAT AS INFLUENCED BY SHELTER AND SOIL WATER,
Frank, A.B., Harris, D.G., and Willis, W.O.
Northern Great Plains Research Center, Department of Plant Science, Mandan, North Dakota 58554.
Agronomy Journal, Vol. 69, No. 6, p 906-910, November-December, 1977. 6 fig, 1 tab, 19 ref.

Descriptors: Micro environment, Windbreaks, Wheat, Irrigation, Irrigation effects, Crop production, Crop response, Soil water, Wind velocity, Leaves.

Field windbreaks have been planted primarily for soil erosion control; subsequently, research has shown that windbreaks have an effect on microclimate and on growth and yield of crops. Other research has shown that plant water relations respond to changes in microclimate. The present work was undertaken to determine the effect of microclimate changes induced by a slat-fence windbreak on the plant water relations of field-grown wheat. Slat-fence barriers were used as windbreaks for studying effects of shelter-modified microclimate on plant water relations of "Waldron" spring wheat, grown on Parshall fine sandy loam under irrigated and dryland soil water regimes. Data were collected on leaf water potential, xylem water potential, stomatal diffusion resistance, canopy temperature, soil water potential, soil water extraction, and grain yield.

77:03F-036
TILLAGE EFFECTS ON WINTER WHEAT PRODUCTION WHERE THE IRRIGATED AND DRYLAND CROPS ARE ALTERNATED,
Unger, P.W.
United States Department of Agriculture, Southwestern Great Plains Research Center, Bushland, Texas 79012.
Agronomy Journal, Vol. 69, No. 6, p 944-950, November-December, 1977. 2 fig, 5 tab, 11 ref, 3 equ.

Descriptors: Wheat, Irrigation, Irrigation effects, Crop production, Cultivation, Crop response, Soil water, Soil moisture, Irrigation efficiency, Dry farming.

While adequately irrigated winter wheat yields are relatively high, dryland wheat yields in the southern Great Plains are only about 700 kg/ha with continuous cropping and about 1,000 kg/ha on a harvested area basis after fallow. This study was conducted to determine if yields could be increased where irrigated and dryland wheat crops are alternated on the same plots. Tillage effects were also studied.

77:03F-037
THE DEPENDENCE OF IRRIGATION REQUIREMENTS ON WATER-TABLE DEPTH IN DRAINED LANDS,
Nikolski, Y.N.
Moscow Institute of Hydromelioration, 19 Pryanishnikova Str., Moscow, Union of Soviet Socialist Republics.
Agricultural Water Management, Vol. 1, No. 2, p 191-196, September 1977. 3 fig, 9 ref, 9 equ.

Descriptors: Drainage, Drainage effects, Irrigation, Irrigation effects, Water table, Crop production, Evapotranspiration, Crop response.

The amount of irrigation water required to maintain an optimal average water content in the root zone for maximum crop yield is dependent on the water-table depth as well as on evapotranspiration. An approximate expression is derived in terms of soil constants for the vertical soil water flux, which may be directed upwards or downwards, above the water table. This has been used in a water-balance equation in order to estimate the irrigation requirement. Satisfactory agreement is found between results calculated using this theoretical relationship and published experimental work.

77:03F-038
EVAPORATION IN HIGH LATITUDES,
Rouse, W.R., Mills, P.F., and Steward, R.B.
McMaster University, Department of Geography, Hamilton, Ontario, Canada.
Water Resources Research, Vol. 13, No. 6, p 909-914, December 1977. 5 fig,
3 tab, 9 ref, 7 equ.

Descriptors: Model studies, Temperature, Evaporation, Latitudinal studies.

A simplified form of the equilibrium model of evaporation predicts evaporation from six subarctic and tundra surfaces with an accuracy of 8%. Input data to the model are net radiation, screen air temperature, and an evaporability factor characteristic of the surface. The radiation and energy balances of the six surfaces are compared.

77:03F-039
ROW SPACING AND DIRECTION EFFECTS ON WATER UPTAKE CHARACTERISTICS OF PEANUTS,
Chin Choy, E.W., Stone, J.F., and Garton, J.E.
Oklahoma State University, Stillwater, Oklahoma 74074.
Soil Science Society of America Journal, Vol. 41, No. 2, p 428-432, March-April, 1977. 5 fig, 2 tab, 14 ref.

Descriptors: Evapotranspiration, Peanuts, Crop response, Crop production.

Peanuts grown in 30-cm wide, north-south rows, lost less water to evapotranspiration than those grown in 90-cm rows or than east-west rows of these spacings. Plants grown in 90-cm wide, north-south rows tended to have the highest water losses. The reason for this phenomenon was not determined, although there is reason to believe net radiation is lower in narrow rows than wide. Yield of peanuts was enhanced by the narrow rows and no orientation effect on yield was noted. Thus, water-use efficiency was increased by both yield effect and water conservation effect. Peanut quality was the same for all treatments. There is no reason to believe that the water conserving effect is unique to peanuts. Research on other crops in similar geometries is to be encouraged.

77:03F-040
THE BROWN-ROSENBERG RESISTANCE MODEL OF CROP EVAPOTRANSPIRATION MODIFIED TESTS IN AN IRRIGATED SORGHUM FIELD,
Verma, S.B., and Rosenberg, N.J.
Nebraska University, Agricultural Meteorology Section, Department of Agricultural Engineering, Institute of Agriculture and Natural Resources, Lincoln, Nebraska 68583.
Agronomy Journal, Vol. 69, No. 2, p 332-335, March-April, 1977. 3 fig, 2 tab, 16 ref, 6 equ.

Descriptors: Model studies, Evapotranspiration, Crop production, Irrigation, Sorghum, Temperatures.

The Brown-Rosenberg resistance model was modified to simplify its calculation and increase its usefulness for estimating evapotranspiration. The model requires inputs of net radiation, air temperature, and vapor pressure and canopy and boundary layer resistance. The first three of these parameters are measured. In the modified version canopy resistance is estimated from a functional dependence on irradiance. The boundary layer resistance is estimated from a functional dependence on windspeed. The modification was tested in an irrigated sorghum field at Mead, Nebraska. The model predictions generally agreed to within 10% on both an hourly and daily basis, with direct lysimetric and Bowen ratio-energy balance measurements of evapotranspiration from the sorghum.

77:03F-041
INFLUENCE OF CONSERVATION-TILLAGE ENVIRONMENTS ON GROWTH AND PRODUCTIVITY OF CORN,
Mock, J.J., and Erbach, D.C.
Iowa State University, Department of Agronomy, Ames, Iowa.
Agronomy Journal, Vol. 69, No. 3, p 337-340, May-June, 1977. 2 fig, 6 tab, 13 ref.

Descriptors: Corn, Crop production, Crop response, Soils, Soil investigations, Soil temperatures.

Research on growth responses of corn to environmental conditions associated with conservation-tillage systems has not been extensively conducted. Therefore, the objectives of this study were to evaluate effects of various tillage systems (fall moldboard plow, till-plant, no-till ridge with and without previous-crop residue) and early planting on growth and productivity of several corn genotypes (including two heterogeneous breeding populations that were improved for cold tolerance by recurrent selection). The experiment was conducted for 2 years on a loam soil, and planting dates were April 1, 1974, and April 30, 1975. Conservation-tillage systems were associated with lower midafternoon soil temperatures during the early growing season and more variability in depth of seed placement. Also, seedling and juvenile plant growth, final plant densities, and grain yields were lower in conservation-tillage systems. These differences were accentuated in the early planting environment of the 1974 experiment. With a relatively normal planting date and equal final plant densities (the environment of the 1975 experiment), grain yields were not affected by tillage treatment. There was no interaction between tillage method and corn genotype. In the central United States Corn Belt, therefore, optimum corn grain yields in conservation-tillage environments will be obtained by the use of planters that assure uniform seed depth and genotypes that display vigorous plant growth and development.

77:03F-042
ONION-SEED YIELD AND QUALITY AS AFFECTED BY IRRIGATION MANAGEMENT,
Brown, M.J., Wright, J.L., and Kohl, R.A.
Snake River Conservation Research Center, Kimberly, Idaho 83341.
Agronomy Journal, Vol. 69, No. 3, p 369-372, May-June, 1977. 1 fig, 2 tab, 15 ref.

Descriptors: Onions, Crop production, Crop response, Irrigation, Irrigation effects, Irrigation practices, Soil moisture, Soil water, Idaho, Furrow irrigation, Tensiometers, Germination.

The effects of soil moisture, sprinkler irrigation, and misting on hybrid onion-seed production were evaluated at Kimberly, Idaho. Sprinkling and misting treatments were included to determine if sprinkler irrigation could be used for onion-seed production, and if evaporative cooling (misting) would alleviate the scalding of umbels at excessively high temperatures. Results showed that reasonable onion-seed yields could be obtained with sprinkler irrigation in spite of anticipated adverse effects on pollination. In areas with high daytime temperatures, misting could be used to cool the umbels, as much as 15 C for about 20 min., although it does not seem necessary for the low 32 to 35 C daytime temperatures at Kimberly. The highest onion-seed yields were obtained with the furrow-irrigation treatment where water was applied when tensiometers at 20-cm depth read about 0.5 bar soil moisture tension (furrow adequate).

77:03F-043
COMPREHENSIVE NITROGEN FERTILIZER MANAGEMENT MODEL FOR WINTER WHEAT,
Jackson, G.D., and Sims, J.R.
Montana State University, Montana Cooperative Service, Bozeman, Montana 59715.
Agronomy Journal, Vol. 69, No. 3, p 373-377, May-June, 1977. 8 tab, 24 ref.

Descriptors: Nitrogen, Fertilizers, Fertilization, Model studies, Wheat, Montana, Soil properties, Climates, Crop production.

Systems for predicting fertilizer N rates on dryland winter wheat in Montana have needed refinement for several years. The objective of this study was to develop a comprehensive N fertilizer management model for dryland winter wheat based on soil properties and climatic factors. Data for multiple regression analysis were gathered from 47 locations representing 4 growing seasons. A stepwise multiple linear regression technique was used to generate equations for predicting optimum grain yield, grain protein content at optimum yield levels, N fertilizer rate needed to achieve optimum yield, post-harvest soil NO3(-)N in surface 30 cm of soil, and grain yield and protein content without N fertilization.

77:03F-044
PEANUT SEED GERMINATION AS RELATED TO SOIL WATER REGIME DURING POD DEVELOPMENT,
Pallas, J.E. Jr., Stansell, J.R., and Bruce, R.R.
United States Department of Agriculture, Agricultural Research Service,
Watkinsville, Georgia 31794.
Agronomy Journal, Vol. 69, No. 3, p 381-383, May-June, 1977. 2 tab, 7 ref.

Descriptors: Crop production, Crop response, Peanuts, Germination, Soil moisture, Soil water, Irrigation, Irrigation practices.

The problem of poor peanut seed germination has appeared to follow exceptionally dry years in Georgia; consequently, the interaction of soil water availability during the growing season and subsequent seed germination were studied. These results are a composite of four years of study under controlled rainfall shelters on Tifton loamy sand, a member of the fine-loamy, siliceous, thermic Plinthic Paleudults, at six soil water levels. Soil water levels involved irrigation at specified soil water tensions in surface 30 or 60 cm. Soil water tension ranged from + 0.2 to greater than 15 bar. Good germination of all varieties was obtained when the average soil water tension in the surface 30 cm was maintained at less than 0.6 bars. On the other hand, allowing "Florigiant" to reach a soil water tension greater than 15 bars during the growing season lowered its percentage of sound mature kernels 34 percent.

77:03F-045
NITROGEN AND CHLORIDE UPTAKE BY IRRIGATED RUSSET BURBANK POTATOES,
Saffigna, P.G., and Keeney, D.R.
Wisconsin University, Department of Soil Science, Madison, Wisconsin 53706.
Agronomy Journal, Vol. 69, No. 2, p 258-264, March-April, 1977. 1 fig, 7 tab, 20 ref.

Descriptors: Potatoes, Crop production, Wisconsin, Nitrogen, Chlorides, Nutrients, Fertilizers, Fertilization, Irrigation, Leaching.

Potato production has become a major agricultural enterprise in the central sand plain of Wisconsin. However, little information is available on the effects of irrigation and fertilization practices on dry matter and N accumulation. This field study was established to determine the effect of reducing irrigation and fertilizer N on the dry matter, and the N and Cl in potatoes grown on a Plainfield loamy sand. Two basic treatments were used. The conventional treatment approximated current recommendations for irrigated potatoes and received 260 kg N/ha (as NH4NO3) in four applications and 45 cm irrigation as 2.4 cm applications every 5 days. The improved treatment was intended to minimize leaching of NO3(-)N. It received 170 kg N/ha in 10 applications (one as S-coated urea and nine as NH4NO3) and 27.0 cm irrigation as 1.0 cm applications every 3 days. Chloride (as KCl) accompanied N on a 1:1 weight basis. Plants were sampled weekly and analyzed for dry matter, total N, NO3(-)N, and Cl.

77:03F-046
INFLUENCE OF THREE SOIL-WATER REGIMES ON ROOT POROSITY AND GROWTH OF FOUR RICE VARIETIES,
Das, D.K., and Jat, R.L.
Indian Agricultural Research Institute, National Bureau of Soil Survey and Land Use Planning, New Delhi, India.
Agronomy Journal, Vol. 69, No. 2, p 197-200, March-April, 1977. 4 fig, 2 tab, 20 ref.

Descriptors: Soil moisture, Soil water, Root systems, Root development, Rice, Saturated soils, Crop production.

A better understanding of the growth response of rice to waterlogged soil conditions is desirable. The objective of this study was to measure the influence of soil water regime on root porosity, growth, and nutrient content of four varieties of rice at various dates after transplanting. Four rice varieties were grown under three soil water regimes (continuous flooding, alternate flooding, and no flooding) in a greenhouse on a clay loam soil. Root porosity, growth of plants and nutrient (N, P, K, Ca, and Mg) content of shoots were determined at four different plant ages (30, 60, 85, and 110 days after transplanting). Root porosity was greatest in plants grown with continuous flooding. Porosity of roots in all four varieties reached maximum values between 30 and 60 days and then started to decline. Padma and BC6 had higher root porosities than IR8 and IR22. High root porosity was associated with greater root length, increased dry weight of roots and shoots, and higher nutrient content in shoots.

77:03F-047
YIELDS AND NUTRIENT ACCUMULATION BY DETERMINATE SOYBEANS, AS AFFECTED BY APPLIED NUTRIENTS,
Terman, G.L.
National Fertilizer Development Center, Soils and Fertilizer Research Branch, Tennessee Valley Authority, Muscle Shoals, Alabama 35660.
Agronomy Journal, Vol. 69, No. 2, p 234-238, March-April, 1977. 2 fig, 5 tab, 12 ref.

Descriptors: Fertilizers, Fertilization, Soybeans, Nutrients, Crop response, Crop production.

Most published results with southern determinate soybeans are concerned with only a single fertilizer treatment and/or one or two sampling dates. Consequently, field experiments were conducted to determine effects of applied N and K on dry matter yields, nutrient concentrations, and nutrient uptake at several sampling dates and on final grain yields. Rates of 0, 86, and 172 kg of applied K/ha and 0 and 70 kg of N were compared in a field experiment on Sango sil in 1973 and K rates of 0, 75, and 150 kg/ha in 1974. Marked responses to applied K were obtained. Maximum dry matter yields and nutrient uptake occurred during the early pod filling stage of growth. Dry matter yields then declined as a result of greater loss of leaf and petiole drop than of increase in grain filling. Concentrations of K in leaves, topgrowth, and grain increased with amount of applied K, but top trifoliate leaf blade concentrations were lower than some published recommended levels for high yields. Marked reciprocal relationships occurred among concentrations of K and Ca or Mg in top trifoliate leaves and topgrowth. Several combinations of N, P, K, and S foliar- and soil-applied during pod filling were also compared in 1976 pot experiment on Sango sil. Grain yields and concentrations of each applied nutrient were increased in leaves and grain. Pod numbers were highly correlated with grain yields.

77:03F-048
CONSERVATION TILLAGE IN THE PACIFIC NORTHWEST,
Papendick, R.I., and Miller, D.E.
United States Department of Agriculture, Agricultural Research Service, Pullman, Washington 99164.
Journal of Soil and Water Conservation, Vol. 32, No. 1, p 49-56, January-February, 1977. 4 fig, 1 tab, 49 ref.

Descriptors: Crop production, Soil erosion, Water conservation, Runoff, Soil surface, Soil properties, Soil management, Land resources, Agriculture.

Despite years of research and development, tillage and cropping practices to conserve soil and water in the Pacific Northwest have not completely achieved the goals of efficient water use and soil protection. Precipitation and irrigation water still run off, and soil losses remain high. In the Palouse Region, for example, where the moldboard plow is widely used, erosion is as great as anywhere in the United States. There is a trend in many areas to reduced tillage and surface residue systems.

77:03F-049
DRAINAGE CONTROL TO DIMINISH NITRATE LOSS FROM AGRICULTURAL FIELDS,
Gilliam, J.W., Skaggs, R.W., and Weed, S.B.
North Carolina State University, Department of Soil Science, Raleigh, North Carolina.
Presented at the 1977 Annual Meeting of the American Society of Agricultural Engineers, June 26-29, 1977, North Carolina State University, Raleigh, North Carolina, p. 1-16. 8 fig, 11 ref.

Descriptors: Drainage, Nitrates, Agriculture, Drainage effects, Drainage water, Drainage systems, Nutrients, Nitrogen.

Flashboard riser type water level control structures were installed in four tile mains or outlet ditches at two locations. Under controlled drainage conditions, there was a large decrease in both nitrate and drainage water lost through the artificial drainage systems. The effect on nitrate ultimately entering surface waters, however, is believed to depend on soil type.

77:03F-050
COMPUTERIZED IRRIGATION SCHEDULING USING NEUTRON PROBES,
Buchheim, J.F., and Ploss, L.F.
United States Department of the Interior, Bureau of Reclamation, Engineering and Research Center, Denver, Colorado 80225.
Presented at the 1977 Annual Meeting of the American Society of Agricultural Engineers, June 26-29, 1977, North Carolina State University, Raleigh, North Carolina, p. 1-12. 5 fig, 3 ref, 6 equ.

Descriptors: Scheduling, Soil moisture, Soil water, Computer programs, Irrigation, Irrigation practices.

The development and evaluation of computer-supported irrigation scheduling are discussed. The use of neutron probes is being initiated in several areas to enhance the scheduling procedure. The results of one year of operation using these procedures in many areas including an analysis on an irrigation district confirmed the practical use of neutron probes.

77:03F-051
CONSERVATION TILLAGE IN THE WESTERN CORN BELT,
Amemiya, M.
Iowa State University, Department of Agronomy, Ames, Iowa 50011.
Journal of Soil and Water Conservation, Vol. 32, No. 1, p 29-36, January-February, 1977. 8 tab, 59 ref.

Descriptors: Crop production, Agriculture, Soil erosion, Soil management, Soil conservation, Water quality, Erosion.

Fertile soils and favorable climate make the western Corn Belt-Iowa, Minnesota, Missouri, and the humid areas of eastern Nebraska and eastern South Dakota-one of the world's outstanding grain-producing regions. For the western Corn Belt to continue to use its productive soils and favorable climate to help meet domestic and world agricultural needs will depend on how prudently the land resource is used. Soil erosion is the dominant limitation to agriculture on at least 30 percent of the region's cropland, and this cropland's potential contribution to watershed sediment yield is very high.

77:03F-052
SOIL CONSERVATION ON AGRICULTURAL LAND: THE CHALLENGE AHEAD,
Davis, R.M.
United States Department of Agriculture, Soil Conservation Service, Washington, D.C. 20250.
Journal of Soil and Water Conservation, Vol. 32, No. 1, p 5-8, January-February, 1977. 5 ref.

Descriptors: Agriculture, Soil conservation, Soil management, Crop production, Erosion, Soil erosion, Water quality.

Agriculture is a dynamic industry. Its technology and economics change constantly. Within this dynamic framework, soil conservationists, for more than four decades now, have tried to keep one objective clearly in view: To bring about improved soil and water management through a voluntary, cooperative program with conservation districts and land users. Today, soil conservationists still find themselves confronted by change and challenge.

77:03F-053
FUTURE USE OF AGRICULTURAL LAND FOR NONAGRICULTURAL PURPOSES,
Spaulding, B.W., and Heady, E.O.
Arkansas University, Department of Agricultural Economics and Rural Sociology,

Fayetteville, Arkansas 72701.
Journal of Soil and Water Conservation, Vol. 32, No. 2, p 88-93, March-April, 1977. 2 fig, 6 tab, 16 ref.

Descriptors: Agriculture, Urbanization, Land use, Land development, Land resources, Land management, Land classification.

A procedure to estimate the acreage of agricultural land needed for nonagricultural purposes in the continental United States to the year 2000 was developed. The acreage to be converted by the turn of the century represents a 2.2 percent reduction in the nation's existing agricultural land base. Overall, our nation's productive capacity in agriculture will not be impaired significantly by this loss of land to nonagricultural purposes. However, the impacts will likely be significant at state and local levels.

77:03F-054
WHEAT CANOPY TEMPERATURE: A PRACTICAL TOOL FOR EVALUATING WATER REQUIREMENTS,
Jackson, R.D., Reginato, R.J., and Idso, S.B.
United States Water Conservation Laboratory, United States Department of Agriculture, Agricultural Research Service, Phoenix, Arizona 85040.
Water Resources Research, Vol. 13, No. 3, p 651-656, June 1977. 6 fig, 27 ref.

Descriptors: Wheat, Temperature, Crop response, Irrigation, Soil water, Soil moisture, Lysimeters, Evapotranspiration, Irrigation efficiency.

Canopy temperatures were measured on durum wheat grown in six differentially irrigated plots. Soil water content was measured by using a neutron-scattering technique at two locations within each plot. Water contents, in 20-cm increments to 160 cm, were determined two to five times per week. Using a sliding cubic smoothing technique, we calculated daily water contents and thus water depletion rates for the entire growing season. Canopy temperatures were measured daily between 1330 and 1440 hours. Air temperatures measured at 150 cm above the soil surface were subtracted from the canopy temperatures to form the difference Tc - Ta. The summation of Tc - Ta over time yielded a factor termed the "stress degree day" (SDD). The SDD concept shows promise as an indicator for determining the times and amounts of irrigations. An expression relating evapotranspiration (ET) to net radiation and Tc - Ta was simplified and tested by using ET measurements with a lysimeter. The expression was used to predict water use by wheat in the six plots. Predicted ET and measured water used agreed reasonably well. The expression may be useful in determining amounts of irrigation water to apply.

77:03F-055
PHOTOSYNTHESIS, TRANSPIRATION, AND LEAF ELONGATION IN CORN SEEDLINGS AT SUBOPTIMAL SOIL TEMPERATURES,
Barlow, E.W.R., Boersma, L., and Young, J.L.
MacQuarie University, School of Biological Sciences, Sydney, Australia.
Agronomy Journal, Vol. 69, No. 1, p 95-100, January-February, 1977. 7 fig, 33 ref.

Descriptors: Plant physiology, Crop response, Soil temperatures, Photosynthesis, Corn, Crop production, Temperature.

The physiology of plant response to low soil temperatures is not well understood. Laboratory studies were conducted to examine the relative sensitivities of rates of leaf elongation, net photosynthesis, and transpiration and the leaf water potential of corn seedlings to decreasing temperature. These parameters were simultaneously monitored, as the soil temperature was decreased from 28 to 10 C at about 4 C increments. The different soil temperatures were imposed during a 10-hour period on 14-day-old plants with seven exposed leaves growing at a 27.5 C air temperature, a 55% relative humidity, and a light intensity of 753 muE/m2/sec. Any decrease of the soil temperature below 28 C decreased the leaf elongation rate. This was attributed to restricted water uptake which lowered the plant water potential and to the temperature decrease of the shoot apical meristem region. Leaf elongation ceased at the plant water potential of -9 bars due to decline of leaf turgor pressure.

77:03F-056

NITROGEN, CHLORIDE, AND WATER BALANCE WITH IRRIGATED RUSSET BURBANK POTATOES IN A SANDY SOIL,

Saffigna, P.G., Keeney, D.R., and Tanner, C.B.

Queensland Wheat Research Institute, 13 Holberton Street, Toowoomba, Queensland 43500, Australia.

Agronomy Journal, Vol. 69, No. 2, p 251-257, March-April, 1977. 3 fig, 6 tab, 22 ref.

Descriptors: Nitrogen, Chlorides, Irrigation, Irrigation effects, Potatoes, Sands, Sprinkler irrigation, Fertilizers, Fertilization, Groundwater, Wisconsin, Lysimeters, Irrigation efficiency.

Large applications of sprinkler irrigation and N fertilizer have been implicated in causing nitrate contamination of groundwater in central Wisconsin. Field and lysimeter experiments were established in 1972 and 1973 on the Plainsfield loamy sand to determine the effect of reducing the amount of sprinkler-irrigation and fertilizer N on potato tuber yields and on the field water and N balance. Two main treatments were used. The conventional (CON) treatment received irrigation water and N fertilizer according to current recommendations. The improved (IMP) treatment received less irrigation water than the CON treatment in both years. A satisfactory mass balance of water, N and CI for potatoes grown in the lysimeters was obtained. Drainage accounted for considerable amounts of the water, N, and CI outputs with nearly all of the remainder going to evapotranspiration and plant uptake. The carefully managed IMP treatment decreased NO3(-)N leaching from 200 to 120 kg N/ha and lowered the overall average NO3(-)N concentration of the leachate from 23 to 16 mg NO3(-)N/liter. However, the additional costs required to effect a small savings in N fertilizer is probably not justified.

77:03F-057

SELECTED IRRIGATION RETURN FLOW QUALITY ABSTRACTS, 1975,

Skogerboe, G.V., Smith, S.W., and Walker, W.R.

Colorado State University, Department of Agricultural and Chemical Engineering, Fort Collins, Colorado 80523.

Publication No. EPA-600/2-77-094, May 1977. 249 p.

Descriptors: Fertilizers, Irrigated land, Irrigation systems, Irrigation water, Nitrates, Phosphates, Return flow, Salinity, Water pollution effects, Water pollution sources, Water quality control.

Research related to the quality of irrigation return flow is being conducted at numerous institutions throughout the western United States. Related work is also underway at other institutions in the United States, as well as other portions of the world. Approximately 100 sources of material have been searched for articles pertinent to the National Irrigation Return Flow Research and Development Program. These articles describe water quality problems resulting from irrigated agriculture, potential technological solutions for controlling return flows, recent research pertinent to return flow investigations, and literature associated with institutional constraints in irrigation return flow quality control. The first annual issue of SELECTED IRRIGATION RETURN FLOW QUALITY ABSTRACTS covered publications printed in 1968 and 1969, while the second annual issue lists publications printed in 1970 and 1971, the third annual issue covers calendar years 1972 and 1973, and the fourth annual issue covers literature published in 1974. This annual issue lists publications printed in 1975. This report was submitted in fulfillment of Grant Number R-800426 under the sponsorship of the Office of Research and Development, Environmental Protection Agency.

77:03F-058

SUNFLOWER YIELD AND WATER USE AS INFLUENCED BY PLANTING DATE, POPULATION, AND ROW SPACING,

Alessi, J., Power, J.F., and Zimmerman, D.C.

United States Department of Agriculture, Northern Great Plains Research Center, Mandan, North Dakota.

Agronomy Journal, Vol. 69, No. 3, p 465-469, May-June, 1977. 4 fig, 4 tab, 8 ref.

Descriptors: Crop response, Crop production, Temperature, Agriculture, North Dakota.

Sunflower has only recently been grown commercially as an oilseed crop in the drier regions of the Northern Great Plains. This study was conducted to acquire preliminary information on seed yield, oil concentration, and water use for oil-type sunflower as affected by planting date, plant population, and row spacing; and to obtain an indication how these results were affected by yearly variation in precipitation and air temperature.

77:03F-059
SHORT-TERM SPRINKLER PATTERNS BY DYE-CONCENTRATION,
McMaster, G.M.
Idaho University, Department of Agricultural Engineering, Aberdeen, Idaho 83210.
Presented at the 1977 Winter Meeting of the American Society of Agricultural Engineers, December 13-16, 1977, Palmer House Hotel, Chicago, Illinois, p. 1-5.
2 fig, 6 ref.

Descriptors: Sampling, Sprinklers, Sprinkler irrigation, Irrigation, Irrigation effects, Irrigation efficiency.

A procedure was tested to determine the sprinkler head pattern resulting from a few revolutions of the head. A fluorescent dye, detectable at low concentration in water, was injected upstream from a sprinkler head. Precipitation collectors were charged with a measured volume of water. The precipitation rate on each collector was determined by measuring dye concentration with a fluorometer. Tests of several time durations were conducted and compared.

77:03F-060
ANALYSIS OF THE DIMENSIONLESS LINEAR CUMULATIVE FREQUENCY DISTRIBUTION OF WATER DEPTHS UNDER SPRINKLER IRRIGATION,
Karmeli, D., and Peri, G.
Colorado State University, Department of Agricultural and Chemical Engineering, Fort Collins, Colorado 80523.
Presented at the 1977 Winter Meeting of the American Society of Agricultural Engineers, December 13-16, 1977, Palmer House Hotel, Chicago, Illinois, p. 1-36.
12 fig, 2 tab, 4 ref, 53 equ.

Descriptors: Sprinkler irrigation, Irrigation, Model studies, Irrigation efficiency, Irrigation effects.

The linear regression model is used to describe sprinkler distribution patterns. The linear fit is found to approximate the distribution very well in a wide range of experimental data. The use of the model allows for additional information regarding irrigation quality parameters. Associated with the linear regression, a new coefficient, UCL, is suggested for practical use.

77:03F-061
ALLOCATION PROCEDURE OF FARM RESOURCES IN RELATION TO SOME IRRIGATION QUALITY PARAMETERS,
Karmeli, D.
Colorado State University, Department of Agricultural and Chemical Engineering, Fort Collins, Colorado 80523.
Presented at the 1977 Annual Meeting of the American Society of Agricultural Engineers, June 26-29, 1977, Raleigh, North Carolina State University, p. 1-15.
1 fig, 3 tab, 5 ref.

Descriptors: Crop production, Agriculture, Irrigation, Irrigation effects, Irrigation systems, Irrigation efficiency, Water allocation.

Land, water, labor and capital are optimally allocated to crops on a farm, using a procedure that also relates to irrigation frequency and level of improvement in the irrigation system. The procedure is based on formulating outputs and expenditures as well as the functions of irrigation frequency--water and yield. The Generalized Geometric Programming is used to solve the objective function as nonlinear equations are involved.

77:03F-062
MANAGEMENT OF IRRIGATION STREAM SIZE FOR IMPROVED RUNOFF WATER QUALITY,
Allen, R.G., Busch, J.R., Lewis, G.C., and Fitzsimmons, D.W.
Idaho University, Department of Agricultural Engineering, Moscow, Idaho.
Presented at the 1977 Winter Meeting of the American Society of Agricultural Engineers, December, 13-16, 1977, Palmer House Hotel, Chicago, Illinois, p. 1-9.
6 fig, 1 tab, 8 ref, 1 equ.

Descriptors: Irrigation, Runoff, Water quality, Irrigation water, Furrow irrigation, Erosion, Sediments, Nutrients, Irrigation efficiency.

A study of water quality changes between applied irrigation water and runoff for two furrow irrigated 0.89 ha plots is reported. Furrow streams on one plot were cutback to minimize runoff and erosion, and the second plot was used as a control. Losses of sediment and nutrients from the cutback-irrigated plot were much less than lost from the control, and the water-use efficiency was 73 percent versus 41 percent for the control.

77:03F-063
CANAL SEEPAGE REDUCTION BY SEDIMENT LADEN WATER,
Edling, R.J.
Nebraska University, Department of Agricultural Engineering, Lincoln Panhandle Station, Scottsbluff, Nebraska.
Presented at the 1977 Winter Meeting of the American Society of Agricultural Engineers, December 13-16, 1977, Palmer House Hotel, Chicago, Illinois, p. 1-15.
3 fig, 3 tab, 4 ref.

Descriptors: Seepage, Canal seepage, Sediments, Sediment load, Economics.

The influence of artificially induced sediment laden water on Interstate Canal seepage loss was studied. The Interstate Canal is the largest canal in the North Platte project. Substantial seepage loss reduction due to sediment laden water was realized in one of the four years studied. The practice of artificially inducing sediment laden water to reduce seepage loss is being threatened by environmental and economical concerns.

77:03F-064
A LYSIMETER SYSTEM FOR WATER TABLE CONTROL,
Shih, S.F., Gascho, G.J., and Mishoe, J.W.
Florida University, Agricultural Research and Education Center, Belle Glade, Florida.
Presented at the 1977 Winter Meeting of the American Society of Agricultural Engineers, December 13-16, 1977, Palmer House Hotel, Chicago, Illinois, p. 1-12.
4 fig, 2 tab, 13 ref.

Descriptors: Lysimeters, Water table, Sugarcane, Irrigation, Irrigation effects, Crop production.

Lysimeters were constructed from plastic-lined, above-ground swimming pools in order to control water tables at 30, 60, and 90 cm below the surface of muck soil for sugarcane culture. Details of the construction and water table maintenance data are included. The water tables were well maintained for a low installation cost of about $20/sq m of soil surface area.

77:03F-065
COMPARISON OF SURFACE-DRAINED AND SUBSURFACE-DRAINED CLAYPAN SOILS,
Walker, P.N.
Illinois University, Department of Agricultural Engineering, Urgana, Illinois 61801.
Presented at the 1977 Winter Meeting of the American Society of Agricultural Engineers, December 13-16, 1977, Palmer House Hotel, Chicago, Illinois, p. 1-6.
5 fig, 1 tab, 3 ref.

Descriptors: Corn, Crop production, Drainage, Irrigation, Irrigation effects, Drainage effects, Furrow irrigation, Sprinkler irrigation.

Corn grown in claypan soil received ten different combinations of drainage and irrigation treatments. One year's yield data indicate no major differences between the drainage treatments or between sprinkler and furrow irrigation. Irrigated plot yields average 9.3 tonnes/ha. Nonirrigated plot yields averaged 4.3 tonnes/ha.

77:03F-066
SOIL AND WATER CONSERVATION PRACTICES FOR POLLUTION CONTROL,
Walter, M.F., Steenhuis, T.S., and Haith, D.A.
Cornell University, Department of Agricultural Engineering, Ithaca, New York 14853.
Presented at the 1977 Winter Meeting of the American Society of Agricultural Engineers, December 13-16, 1977, Palmer House Hotel, Chicago, Illinois, p. 1-19. 6 tab, 42 ref.

Descriptors: Soil conservation, Water conservation, Water quality, Water quality control, Pollution, Pollutants.

Policy concerning BMP's to control agricultural nonpoint source pollution has yet to be developed. There has been a tendency to equate BMP's with soil and water conservation practices. SWCP's must be capable of enhancing water quality if they are to be used as BMP's. This paper discusses the effect of SWCP's on water quality.

77:03F-067
DRIP IRRIGATION,
Shoji, K.
Scientific American, p 62-68, November 1977. 5 fig, 1 tab.

Descriptors: Irrigation, Irrigation systems, Irrigation efficiency, Crop production, Soil water, Soil water movement, Water conservation, Saline water, Salinity.

In this system plastic pipes laid on the surface of the ground deliver water to plants drop by drop. The system reduces stress on the plant, conserves water and works well with saline water.

77:03F-068
ENERGY AND IRRIGATION SYSTEM PLANNING,
Humpherys, A.
Snake River Conservation Research, Agricultural Engineering Division, Kimberly, Idaho.
Irrigation Age, Vol. 11, No. 7, p 74-75, April 1977. 2 tab.

Descriptors: Irrigation systems, Irrigation engineering, Irrigation practices, Irrigation design, Economics.

Most irrigators are concerned with the spiraling costs and threatened shortages of energy for irrigation pumping. Energy costs are expected to continue increasing and, in some areas, limited energy supplies may restrict irrigation development. Irrigation systems are normally based on a least cost design. With low energy costs, for example, it has been more economical to use smaller pipes than would be used for minimum-energy designs. Future systems may require a minimum-energy design to minimize energy inputs. As energy costs increase, this also may be the least cost design.

77:03F-069
NEUTRON PROBE PROMISING SCHEDULING TOOL,
Dronsfield, A.S.
Bureau of Reclamation, Irrigation Management Services Branch, Lower Colorado Region, Boulder City, Nevada.
Irrigation Age, Vol. 11, No. 8, p 38, May-June, 1977. 1 fig.

Descriptors: Soil water, Soil moisture, Crop production, Irrigation, Irrigation efficiency, Irrigation practices.

The success of the irrigation farmer has largely depended on his judgment of when to irrigate and how much water to apply. His success has always been challenged by the effectiveness with which he applied water to his crops. Proper irrigation management has been, and today is, largely an "art." The Neutron Probe is now a field tool and can be used to determine when to irrigate and how much water to apply. It has been recognized as an excellent research instrument for determining soil moisture content.

77:03F-070
WORLD'S LARGEST SOLAR-POWERED IRRIGATION SYSTEM OPERATING IN ARIZONA: RISING ENERGY COSTS CAUSE EXPLORATORY VENTURE,
Irrigation Journal, Vol. 27, No. 4, p 14-15, July-August, 1977.

Descriptors: Arizona, Irrigation systems, Irrigation practices, Solar radiation, Pumping plants.

The world's largest solar-powered irrigation system was dedicated in late April at Northwestern Mutual Life Insurance Company's Gila River Ranch, southwest of Phoenix. The system, developed by the Columbus Laboratories of Battelle Memorial Institute, includes a 50-horsepower pump capable of delivering up to 10,000 gallons of irrigation water per minute at peak operation.

77:03F-071
IRRIGATED SOYBEANS: BIG YIELDS FROM A LITTLE TIMELY WATER,
Schleicher, J.
Irrigation Age, Vol. 11, No. 7, p 16, 18, 20, April 1977. 2 fig.

Descriptors: Soybeans, Crop production, Irrigation, Irrigation efficiency, Irrigation water, Crop response.

As irrigation presses eastward, Midwestern farmers are more and more interested in adapting irrigation to their own crop production programs. One frequent comment: "What about irrigating soybeans?" Surprisingly, soybean irrigation already has a strong hold in the Midwest. In Nebraska last year, an estimated 200,000 acres of soybeans were produced under irrigation. Some 120,000 acres of soybeans were grown with supplemental water in Texas. Another 90,000 acres were irrigated in Missouri in 1976, 35,000 acres in Kansas, and an estimated 17,000 acres in Oklahoma.

77:03F-072
INTERDISCIPLINARY MODELS OF WATER SYSTEMS,
Shahane, A.N.
Central and Southern Florida Flood Control District, Environmental Systems Engineering Division, West Palm Beach, Florida 33402.
International Commission on Irrigation and Drainage Bulletin, Vol. 26, No. 1, p 58-69, January 1977. 1 fig, 35 ref.

Descriptors: Model studies, Simulation analysis, Water supply, Computer programs, Computers, Mathematical studies, Water conservation, Water delivery, Water resources.

Due to the complex structure of water systems, modern efforts are largely geared to the multidisciplinary analysis of these water systems. The scope of this paper is to present in a logical manner the various interdisciplinary concepts and formulations involved in the modeling of the water system. The main rational behind this effort is to broaden the isolated perspective by getting exposed to the other equally important aspects of water systems. Based on the discussion of the previous sections, it can be realized that the success of these modeling efforts is dependent on the data base, computer capacity, the validity of assumptions, estimation procedure for rate coefficients or arbitrarily chosen weights and finally the verification for the outcome. Since every situation is unique in itself, the model building procedure varies significantly and thus its application becomes an art rather than a science. With the understanding of these interdisciplinary interactions and their mathematical formulation coupled with necessary weighing procedures, it is hoped that water systems can be adequately modeled to include real-world complexities in the near future.

77:03F-073
POLICY OF PRICING IRRIGATION WATER IN ENGLAND AND WALES,
Ministry of Agriculture, Great Britain.
Land Drainage Service, Ministry of Agriculture, Fisheries and Food, Great Britain.
International Commission on Irrigation and Drainage, Vol. 26, No. 1, p 20, 30, January 1977.

Descriptors: Irrigation water, Irrigation, Irrigation practices, Pricing, Water, Water demand, Economics.

Irrigation of farm crops in England and Wales is supplementary to the natural rainfall which can provide all the water required by the crops in many years, this being particularly true in the wetter western areas. It is therefore mainly used for high value crops such as early and main crop potatoes and in market gardens. The driest area is South Eastern England, and it is estimated that the frequency of irrigation to maintain easily available soil moisture at all times between April and September is 20 years out of 20 years. Unlike many countries, where irrigation is an absolute necessity to maintain crop growth, there are no large irrigated areas dependent on a water supply system which is controlled by governmental agencies or local irrigation boards. Since it is the choice of each individual grower whether to use irrigation on the farm or market garden, the areas of irrigated land are often quite small, and widely separated from those of other irrigators. Consequently, each user takes the water from a variety of often widely spaced and differing ground and surface water sources, or from the public water supply mains.

77:03F-074
RATIONALIZATION OF IRRIGATION RATES IN A DEVELOPING COUNTRY,
Gole, C.V., Amble, V.N., and Chopra, M.M.L.
Central Water Commission, Government of India, New Delhi, India.
International Commission on Irrigation and Drainage, Vol. 26, No. 1, p 31-40, 49, January 1977. 1 tab, 6 ref.

Descriptors: Irrigation water, Irrigation, Irrigation practices, Pricing, Water, Water demands, Economics.

The problem of fixation of irrigation rate assumes particular importance in a developing country like India where the State has to assume responsibility for the large-scale supply of irrigation. The irrigation rate has then to be determined balancing two opposing considerations. On the one hand, it is necessary to recover the costs and even a share of the benefit received by the irrigator in the interest of resource mobilization for further development as the benefit of irrigation accrues only to a small section of the population. On the other hand, the producer has to be provided the incentive for increasing production through greater utilization of irrigation. The paper reviews the existing practices with regard to irrigation rates in various States of India and some other countries and discusses the principles for arriving at a rational structure of irrigation rates.

77:03F-075
GYPSUM BLOCKS, TENSIOMETERS RELIABLE SOIL MOISTURE MONITORS,
Irrigation Age, Vol. 11, No. 7, p 31, 40, 48, April 1977. 1 fig, 4 tab.

Descriptors: Tensiometers, Soil moisture, Soil water, Crop production, Irrigation, Irrigation efficiency.

Two dependable, easy-to-use methods for irrigation scheduling are electrical resistance blocks and tensiometers. Both systems will help conserve water and increase yields. A brief run-down on each with suggestions on how to use them is presented.

77:03F-076
SPRINKLER IRRIGATION PRACTICES AND WATER LOSSES: WATER SHORTAGES UNDERLINE NEED FOR CONSERVATION,
Duble, R.L.

Texas A and M University, Agricultural Extension Service, College Station, Texas.
Irrigation Journal, Vol. 27, No. 2, p 16-17, 20, 46, March-April, 1977. 3 fig.

Descriptors: Sprinkler irrigation, Irrigation practices, Irrigation systems, Water conservation, Water resources, Turf, Irrigation efficiency.

Having witnessed the effects of a water shortage in many sections of the country during the summer of 1976, the value and need for conservation of water can be appreciated. Since scientists forecast more extensive droughts throughout the next decade, people must become more conscious of water use. In order for there to be adequate water supplies for turf irrigation in the future, careful management of water resources is necessary and must be implemented now.

77:03F-077
IRRIGATION IN WYOMING,
Brosz, D.J.
Wyoming University, Department of Engineering, Laramie, Wyoming.
Proceedings of the 1977 Annual Technical Conference, Irrigation For All Reasons, p 173-175, February 13-15, 1977.

Descriptors: Irrigation, Wyoming, Irrigation practices, Resources, Resource development, Water, Water conservation.

Wyoming has the opportunity of finance, through minerals, its own water projects; any size, without having to obtain money from the federal government. Now, state funds made available for loans can be authorized for: (1) Reclamation of new lands (irrigation); (2) Development of new water supplies for existing irrigated land that is short of water supplies; (3) Construction of reservoirs, diversion works, canals, pipelines, pumping stations, etc.; and (4) Development of groundwater.

77:03F-078
FREQUENT IRRIGATION MORE EFFICIENT,
Martin, W.W.
United States Department of Agriculture, Agricultural Research Service, Peoria, Illinois.
Crops and Soils Magazine, Vol. 29, No. 5, p 10-12, February 1977. 3 fig.

Descriptors: Irrigation, Irrigation practices, Irrigation effects, Soil water, Soil moisture, Fertilizers, Irrigation efficiency.

Frequent light irrigations on sandy soil save water and the energy to pump it and also reduce the amount of fertilizer nitrogen moving below the reach of plant roots as a potential groundwater pollutant.

77:03F-079
DRIP AND SPRINKLER IRRIGATION OF CARROTS AND ONIONS,
Melstad, J.D., and DeBoer, D.W.
Montana Department of Health and Environmental Sciences, Subdivision Bureau, Montana.
Presented at the 1977 Annual Meeting of the American Society of Agricultural Engineers, June 26-29, 1977, Raleigh, North Carolina, North Carolina State University, p. 1-13. 1 fig, 6 tab, 8 ref.

Descriptors: Carrots, Onions, Sprinkler irrigation, Irrigation systems, Irrigation.

One carrot and two onion varieties were drip and sprinkler irrigated. Drip yields were greater than sprinkler yields when equal gross amounts of water were used. Drip onions and carrots were larger on the average than sprinkler onions and carrots.

77:03F-080
NEMATICIDE DISTRIBUTION UNDER A DRIP EMITTER,
Garvey, P.M., and Chesness, J.L.
Georgia University, Department of Agricultural Engineering, Athens, Georgia.

Presented at the 1977 Annual Meeting of the American Society of Agricultural Engineers, June 26-29, 1977, Raleigh, North Carolina, North Carolina State University, p. 1-16. 3 fig, 3 tab, 17 ref.

Descriptors: Nematocides, Soils, Soil properties, Irrigation, Irrigation effects, Irrigation systems.

Distribution of nematicide in the soil when applied at different concentrations through a drip irrigation emitter was studied. Thirty, eight hundred, and fifteen hundred ppm concentrations were used and soil volumes exposed to lethal concentrations of the nematicide were determined for each.

77:03F-081
PLANNING SYSTEMS TO MAXIMIZE QUALITY AND PROFIT,
Bean, E.L.
Irrigation Specialist, Lake Elsinore, California.
Proceedings of the 1977 Annual Technical Conference, Irrigation For All Reasons, p 67-69, February 13-15, 1977.

Descriptors: Irrigation, Irrigation practices, Irrigation design, Turf, Turf grasses, Water conservation, Soils, Sprinkler irrigation, Irrigation systems.

Various design factors as related to irrigation systems are presented and discussed with particular emphasis on turf irrigation systems.

77:03F-082
SCHEDULING AND MONITORING IRRIGATION WITH INFRARED PHOTOGRAPHY,
Pitney, M.
Crop Protection, Incorporated, Umatilla, Oregon.
Proceedings of the 1977 Annual Technical Conference, Irrigation For All Reasons, p 176-177, February 13-15, 1977.

Descriptors: Scheduling, Irrigation, Irrigation practices, Soil moisture, Soil water, Infrared radiation, Crop production, Crop response.

Aerial infrared photography was originally developed to detect camouflage during the war. Today it is being used in agriculture to identify plants which are under stress from disease, moisture and nutrients. By interpretation of the infrared reflectance, as recorded on film, it is possible to distinguish between healthy and unhealthy foliage. The value of photography is in the early detection of the stressed plants. The photography also makes the application of corrective measures quick and efficient.

77:03F-083
GROWTH OF SPRINKLER SIX TIMES FASTER THAN FURROW IRRIGATION,
Irrigation Age, Vol. 11, No. 5, p 28, 48, February 1977. 1 fig, 1 tab.

Descriptors: Sprinkler irrigation, Furrow irrigation, Irrigation methods, Irrigation practices, Irrigation systems.

There has recently been a substantial increase in the level of prices for grains both in world markets and in the United States. Sprinkler irrigation accounts for by far the major portion of the growth in irrigated areas in the United States. Between 1974 and 1975 the rate of growth of sprinkler irrigation was 6.2 times the rate of growth of gravity irrigation. The rapid increase in center pivot irrigation accounts for a major proportion of this growth in sprinkler irrigation.

77:03F-084
SOLAR IRRIGATION SYSTEM BEGINS OPERATING IN NEBRASKA,
Irrigation Journal, Vol. 27, No. 5, p 37, September-October, 1977. 1 fig.

Descriptors: Irrigation, Irrigation practices, Irrigation systems, Solar radiation, Nebraska.

One of this country's first crop irrigation systems to be powered by solar energy, began operating the end of July in Mead, Nebraska, after dedication ceremonies lead by Nebraska Governor J. James Exon. The solar unit, designed by the Massachusetts Institute of Technology's Lincoln Laboratory, will use approximately 120,000 solar cells to convert the sun's rays into electricity. The unit drives a ten horsepower pump to irrigate 80 acres of corn and soybeans in the summer. In addition to irrigation, the solar powered system will be used during the fall and winter to dry crops that will be harvested from the field.

77:03F-085
WATER'S KEY TO PROFITABLE ALFALFA SEED PRODUCTION,
Irrigation Age, Vol. 12, No. 2, p 38, 40, October 1977. 3 fig.

Descriptors: Alfalfa, Crop production, Irrigation, Irrigation efficiency, Irrigation practices, Washington, Seeds.

Water for irrigation, or the lack of it at critical times in the growing season, has turned the western end of Walla Walla County, Washington into one of the nation's prime locations for alfalfa seed production. Stan Wagoner of Touchet, who raises 250 acres of seed each year says irrigation water for the area comes from the Blue Mountains. Unfortunately, water flow from the mountains stops the first of June and doesn't resume until September. This limits the growing of row crops which require summer-long irrigation. But for alfalfa seed, the availability of water is suitable.

77:03F-086
EVAPORATIVE COOLING OF PEACH TREES TO BREAK REST AND DELAY BLOOM,
Chesness, J.L., Hendershott, C.H., and Couvillon, G.A.
Georgia University, Department of Agricultural Engineering, Athens , Georgia.
Presented at the Annual Meeting of the American Society of Civil Engineers, Paper No. 76-2039, June 27-30, 1976, Lincoln, Nebraska. 12 p, 2 fig, 3 tab, 10 ref.

Descriptors: Peaches, *Sprinkler irrigation, *Evaporation, *Model studies, Orchards, Irrigation systems, Irrigation effects, Irrigation practices, Forecasting.

The Utah Pheno-Climatography Model was used to predict rest completion and bloom dates for Loring Peach Trees. Individual tree sprinklers with an application rate of .086 per hour (.218 cm/hr) were utilized over a 13-day period to achieve a 14-day bloom delay.

77:03F-087
THE DEVELOPMENT OF A FURROW-MULCH RIDGER,
Richey, C.B., and Griffith, D.R.
Purdue University, Department of Agricultural Engineering, Lafayette, Indiana.
Presented at the 1976 Winter Meeting of the American Society of Agricultural Engineers, December 14-17, 1976, Chicago, Illinois. 18 p, 7 fig, 3 tab, 16 ref.

Descriptors: *Furrow irrigation, *Mulching, *Cultivation, Surface irrigation, Erosion, Erosion control, Furrows, Flow resistance, Soybeans, Weed control, Plant growth.

A tillage tool to form ridges for row crops but leave residue on the surface in the furrows has been developed. It gives promise of combing early plant growth and weed control approaching plowing with moisture conservation and erosion control approaching the no-till system.

77:03F-088
OPTIMAL ON-FARM ALLOCATION OF IRRIGATION WATER,
Trava, J., Heermann, D.F., and Labadie, J.W.
Escuela Nacional de Agricultura, Colegio de Postgraduados, Chapingo (Mexico).
Presented at the Annual Meeting of the American Society of Agricultural Engineers, Paper No 76-2040, June 27-30, 1976, Lincoln, Nebraska. 14 p, 4 tab, 23 ref.

Descriptors: *Irrigation water, *Optimization, *Water allocation, Model studies, Simulation analysis, Crop production, Systems analysis, Water delivery.

The USDA-ARS Scheduling Program is a powerful tool to assist management in the efficient use of irrigation water on the farm. The Water Management Program incorporating an optimization technique provides a tool for scheduling irrigation within constraints of water and labor. The application of systems analysis in making operational real-time management decisions has far-reaching possibilities for further development. More complex objective functions and additional constraints will provide even more assistance to management. The application of the Dantzig-Wolfe decomposition principle to large-scale water management problems demonstrates a feasible way of using systems analysis for operational problems.

77:03F-089
HOW ACCURATE ARE SHOP-MADE ORIFICE PLATES,
Ree, W.O.
Agricultural Research Service, Water Conservation Structures Laboratory, Stillwater, Oklahoma.
Transactions of the American Society of Agricultural Engineers, Vol. 20, No. 2, p 298-300, March-April, 1977. 3 fig, 2 tab.

Descriptors: *Irrigation, *Flow measurement, *Orifice flow, Orifices, Measurement, On-site data collections, Equipment, Gages, Flow, Irrigation ditches, Irrigation engineering, Water delivery, Irrigation efficiency.

Efficient use of irrigation water may require field measurement of furrow flows. A plate with a circular orifice, together with a simple hook gage (both readily made in any sheet metal shop), can be used to measure the flows. However, the orifice may not be perfect, and its accuracy is doubtful. Tests of a sample lot of orifice plates showed that errors in flow measurement could be as large as 15% for a 2.54-cm diameter orifice. For a 8.89-cm diameter orifice, the maximum error would probably be about 2%. The errors are tolerable for rough flow measurements but not for a more accurate measurement. The head measuring technique was checked and found to be satisfactory.

77:03F-090
IRRIGATION MANAGEMENT OF SHORT-SEASON, HIGH-DENSITY COTTON,
Mohammed, R.A., and Fangmeier, D.D.
Arizona University, Department of Soils, Water and Engineering, Tucson, Arizona.
Presented at the 1976 Winter Meeting of the American Soceity of Agricultural Engineers, December 14-17, 1976, Chicago, Illinois. 9 p, 4 tab, 17 ref.

Descriptors: *Irrigation systems, *Cotton, *Soil moisture, *Crop production, Irrigation, Soil water, Crop response, Nutrients, Fertilization, Nitrogen, Water management (applied).

An available soil moisture depletion of 50 to 55% at irrigation will give the highest yields for short-season, high-density cotton. This is compared to about 65% for conventional cotton. Changing the scheduling criteria during the season tended to reduce yields. Application of 100 pounds of N per acre appears adequate for the soils studied. This provided adequate nitrogen for plant growth but did not result in high petiole nitrate values late in the season. For highest yields irrigation termination should be based on observations of boll load and maturity. Later irrigations tend to delay boll opening while terminating too early reduces yields and fiber quality. Careful monitoring of soil moisture and plant condition is both necessary and satisfactory for irrigation scheduling. With experience, feel and appearance of soil moisture condition were adequate for irrigation scheduling. Other methods were more expensive and time consuming but were no better than field observations. Yields were comparable to those obtained with conventional cotton. Water requirements were similar to those for conventional cotton. Early termination reduced the number of irrigations by one and in 1974 reduced the yield by 17%.

77:03F-091
ROW CROP "DRIP" IN FLORIDA: WATER AND FERTILIZER SAVINGS SPEED ACCEPTANCE,
Irrigation Journal, Vol. 27, No. 3, p 48-49, May-June, 1977. 7 fig.

Descriptors: Irrigation, Irrigation systems, Irrigation practices, Fertilization, Crop production, Florida, Water conservation.

Several years of commercial use of drip irrigation in San Diego County, California to grow tomatoes, cucumbers, squash, strawberries and peppers has demonstrated anywhere from 25 to 50 percent water savings, to say nothing of the improved crop production and quality. Commerical vegetable crop acreage under drip or trickle irrigation has soared from 1,500 to 4,500 acres between 1975 and 1976.

77:03F-092
DRIP IRRIGATION MANAGEMENT,
Davis, S.
United States Department of Agriculture, Agricultural Research Service, Riverside, California.
Water and Irrigation, p 14-15, 29-30, November 1977. 2 fig.

Descriptors: Irrigation, Irrigation systems, Irrigation practices, Irrigation efficiency.

Management is unquestionably the most important factor in the use of drip irrigation. To be successful and to accomplish its purpose, drip irrigation requires sound decisions on the part of designers, installers and operators. If the proper equipment is not selected for the soil and water conditions and the equipment installed and operated as designed, then drip irrigation will not fulfil its full capacity to most efficiently utilize energy and water.

77:03F-093
WATER--A CRISIS MORE SERIOUS THAN ENERGY,
Jauregui, L.U.
United Nations Center for Economic and Social Information, OPI/CESI NOTE WATER/14.
Magazine of the International Water Resources Association, Vol. 2, No. 1, p 25-26, March 1977.

Descriptors: Water, Water conservation, Water supply, Water resources, Water supply development.

The demand on the world's finite water supply is growing daily, because of the increased population, the concentration of people in certain areas and the industrialization process. At the same time, the quality of water has deteriorated because of these factors. We must take care of our water supply. And to do that, we have to change our attitude towards it.

77:03F-094
DRIP/TRICKLE IRRIGATION SCHEDULING,
Rodriguez, R.
Superior Farming Company, Department of Irrigation Engineering, Bakersfield, California.
Water and Irrigation, p 21-26, November 1977. 1 tab.

Descriptors: Irrigation, Irrigation practices, Irrigation efficiency, Irrigation methods, Soil moisture, Evapotranspiration.

The preliminary results obtained so far have been plotted. The applied water, crop ET and the soil moisture content are plotted against time. Applied water and ET are plotted in inches per week, every week. The moisture content (as measured with the neutron probe) is shown in inches of water per foot of soil.

77:03F-095
SEEPAGE CONTROL BY PARTICLE SIZE SELECTION,
Hauser, V.L.
United States Department of Agriculture, Agricultural Research Service, Grassland-Forage Research Center, Temple, Texas 76501.
Presented at the 1977 Annual Meeting of the American Society of Agricultural Engineers, June 26-29, 1977, Raleigh, North Carolina, North Carolina State University, p 1-10. 5 fig, 1 tab, 12 ref.

Descriptors: Seepage, Canal seepage, Hydraulic conductivity, Soil particles, Clays.

The hydraulic conductivity of soils can be substantially reduced by the addition of gravel or aggregates which are at least 15 times larger than the particle size of the soil. The amount of clay required to control seepage can be reduced by half by the addition of aggregates at least 15 times larger than the particle size of the base soil.

77:03F-096
SIMULATING THE RESPONSE OF CORN TO IRRIGATION IN HUMID AREAS,
Barfield, B.J., Duncan, W.G., and Haan, C.T.
Kentucky University, Department of Agricultural Engineering, Lexington, Kentucky 40506.
Presented at the 1977 Annual Meeting of the American Society of Agricultural Engineers, June 26-29, 1977, Raleigh, North Carolina, North Carolina State University, p 1-23. 5 fig, 1 tab, 21 ref, 1 append.

Descriptors: Simulation analysis, Model studies, Corn, Irrigation, Irrigation effects.

A description is given of the Duncan Model for simulating the growth and yield of corn. The accuracy of the model for predicting yields of irrigated and non-irrigated corn is evaluated using 12 plot years of data.

77:03F-097
CENTER PIVOT WITH DROP OUTLETS DIRECTS WATER TO ROOT ZONE,
Rodgers, N.
Littlefield, Texas.
Irrigation Age, Vol. 11, No. 5, p 36-37, 39, February 1977. 2 fig.

Descriptors: Irrigation efficiency, Water conservation, Irrigation methods, Irrigation practices, Surface irrigation, Evaporation.

The use of a pivot sprinkler now on loan to the Texas Agricultural Experiment Station (TAES) could revolutionize sprinkler systems where evaporation losses are high due to wind velocity. The newest idea in center pivot irrigation and an old idea called furrow diking to hold rainfall have been combined at the TAES in Lubbock. The melding of the latest ideas in irrigation and the hold-over damming practice from the dust bowl days is a totally new way to get maximum returns out of a limited amount of water.

77:03F-098
STRAIGHT SHOT HERBIGATION,
Welsh, G.
NEBCO Corporation, Holyoke, Colorado.
Irrigation Age, Vol. 11, No. 5, p 46, February 1977. 2 fig.

Descriptors: Herbicides, Sprinkler irrigation, Colorado, Irrigation practices, Crop production, Corn.

Direct injection of a herbicide through sprinklers has not been attempted on a large scale in Colorado. At least not until last year when Gene Welsh, Manager of NEBCO Corporation in Holyoke, applied straight Sutan+ with atrazine through center pivots on several circles of corn. Most growers who herbigate corn dilute the chemical in a holding tank before injecting it into the sprinkler. Because herbicides require small amounts of chemical per acre, many farmers claim it is too difficult to accurately inject the proper rates in this manner, so they blend it with large batches of water before injection. This popular method has proved to be effective but according to Welsh, who has used both methods, "It's definitely easier to inject the straight herbicide. It's a trouble-free process and calibration is much simpler."

77:03F-099
SOIL PROPERTIES AND IRRIGATION,
Grimes, D.W.
California University, Department of Land, Air and Water Resources, Water Science and Engineering Section, Davis, California.
Proceedings of the 1977 Annual Technical Conference, Irrigation For All Reasons, p 40-44, February 13-15, 1977. 2 fig, 3 tab, 8 ref.

Descriptors: Soils, Soil properties, Irrigation, Irrigation effects, Root development, Soil moisture, Soil water, Soil investigations, Soil environment, Soil physical properties.

Consideration of all soil properties important to water management decisions is beyond the scope of this report. Emphasis is placed on some techniques for using water related properties of soils in management decisions and impedance characteristics that reduce effective plant root extension.

77:03F-100
TAILORING YOUR SOIL FOR DRAINAGE AND IRRIGATION,
Daniel, W.H.
Purdue University, Department of Agronomy, Lafayette, Indiana.
Proceedings of the 1977 Annual Technical Conference, Irrigation For All Reasons, p 54-58, February 13-15, 1977.

Descriptors: Irrigation, Drainage, Irrigation effects, Drainage effects, Soils, Soil properties, Turf, Turf grasses, Irrigation design, Irrigation efficiency.

In much of the world, one of the most evident limitations of climate is the lack of available water. The fantastic advancement of the irrigation industry has been matched by the creative ideas of current installations. In the management of fine turf areas, the reduction of the limitations has been the target for many turf managers. Irrigation improvements have given most turf managers excellent tools for the day-by-day application of water at preferred quantities, at preferred times and under uniform application conditions. A study of several 18-hole golf course irrigation designs reveals that the number of heads being used vary from 800 to 1200. These, when combined with satellites and controllers for individual operations of the valves and heads, become effective systems. Many, in fact, most turf areas are developed on existing natural soil. Obviously, this includes a wide variety of soil types, each having varying infiltration and drainage potentials. For intensely used turf areas, extensive soil modifications have evolved as systems of construction. Four of these-vertical trenching, sand bedding, Purr-wick and PAT systems should be of interest.

77:03F-101
DRIP AS SUPPLEMENTAL IRRIGATION,
Nye, J.R.
Trickl-Eez Company, Saint Joseph, Michigan.
Proceedings of the 1977 Annual Technical Conference, Irrigation For All Reasons, p 73-76, February 13-15, 1977.

Descriptors: Supplemental irrigation, Irrigation systems, Irrigation practices, Water conservation, Irrigation efficiency.

The use of drip or trickle irrigation as a supplement to natural rainfall is finding increased usage throughout the Midwest, Eastern and Southern states. By using technology developed mainly in California and the other western states, where drip irrigation has found widespread use as an efficient labor saving method of irrigation, growers who have never irrigated before are adapting it to orchards, vineyards, vegetable croplands, and it may even find usage in field crops.

77:03F-102
FERTILIZATION WITH DRIP IRRIGATION: CONCEPTS, PRACTICES AND PROBLEMS,
Francis, L.
Agrispect, Incorporated, Riverside, California.
Proceedings of the 1977 Annual Technical Conference, Irrigation For All Reasons, p 80-83, February 13-15, 1977. 2 fig.

Descriptors: Irrigation, Irrigation effects, Irrigation practices, Fertilization, Fertilizers, Nutrients.

Fertilizer needs of our crops can be largely applied by means of injection through the drip irrigation system, so long as the proper equipment is used and the chemicals used are thoroughly understood.

77:03F-103
PECULIARITIES OF DRIP IRRIGATION SYSTEM DESIGN,
Olson, B.R., Jr.
Olson Engineering Systems, Indio, California.
Proceedings of the 1977 Annual Technical Conference, Irrigation For All Reasons, p 84-87, February 13-15, 1977.

Descriptors: Irrigation, Irrigation systems, Irrigation practices, Soils, Soil properties, Water conservation, Irrigation design, Sprinkler irrigation.

Drip irrigation is generally considered as a point source application of water at a rate that does not exceed the basic intake rate of the soil. There are certain criteria or "peculiarities" concerning drip irrigation system design as compared to sprinkler or surface irrigation systems. The design engineer is responsible for critically analyzing these criteria.

77:03F-104
BUYING AUTOMATIC IRRIGATION,
Kennedy, S.
Weeds, Trees, and Turf, Vol. 16, No. 1, p 15, 18, January 1977. 1 fig.

Descriptors: Irrigation, Irrigation practices, Irrigation systems, Irrigation efficiency, Automation, Automatic control, Turf.

After 44 years with the same irrigation system, the Columbus Country Club decided to replace it. Here, Superintendent Steven Kennedy tells how he went about doing so and offers some advice to superintendents who plan to replace their systems.

77:03F-105
A LOOK AT THE DRIP/TRICKLE INDUSTRY,
Fraser, G.O., Jr.
Water and Irrigation Magazine.
Water and Irrigation, p 5-11, 27-28, November 1977. 5 fig, 2 tab.

Descriptors: Irrigation, Irrigation efficiency, Irrigation practices, Water conservation.

Leaders of the drip/trickle irrigation industry present their ideas regarding the state-of-the-art of this type of irrigation.

77:03F-106
CAN SUNSHINE POWER THE IRRIGATION PUMP?
Abernathy, G.H., and Mancini, T.R.
New Mexico State University, Department of Agricultural Engineering, Las Cruces, New Mexico 88003.
Agricultural Engineering, Vol. 58, No. 10, p 39-40, October 1977. 1 fig.

Descriptors: Irrigation, Irrigation practices, Pumps, Pumping, Plants, Solar radiation, New Mexico, Electrical equipment, Electricity, Electrical power production, Electric power.

The Torrance County Land and Livestock Company in New Mexico's Estancia Valley is the site of the new experimental solar-powered pumping plant funded by the State of New Mexico and ERDA. Sandia Laboratories engineered the pumping system. New Mexico State University will conduct the agricultural experiments. Three crops will be grown yearly.

77:03F-107
SOLAR ENERGY TO POWER IRRIGATION PUMPS,
Agricultural Engineering, Vol. 58, No. 7, p 41-42, July 1977. 2 fig.

Descriptors: Irrigation, Irrigation practices, Pumps, Pumping plants, Pumping, Solar radiation, New Mexico, Electrical equipment, Electricity, Electrical power production, Electric power.

The sun powers the sump pump in the experimental irrigation system now operating at Gila Bend, Arizona. The system, developed by Battelle Memorial Institute with financial backing by Northwestern Mutual Life Insurance Company, delivers 10,000 gpm to 25,000 acres planted in cotton, wheat, barley, alfalfa and safflower.

77:03F-108
SHOULD YOU BE USING NITRAPYRIN?
Walsh, L.M.
Wisconsin University, Department of Soil Science, Madison, Wisconsin.
Crops and Soils Magazine, Vol. 30, No. 1, p 8-10, October 1977. 1 fig, 2 tab.

Descriptors: Nitrogen, Fertilizers, Fertilization, Nutrients, Crop production.

A new product called N-Serve (nitrapyrin) has been getting a lot of attention since its commerical introduction last fall. This product is designed to cut losses of nitrogen fertilizer.

77:03F-109
ROUNDTABLE: IRRIGATION-FERTIGATION,
Caldwell, A.C., Murphy, L.S., Tucker, B.B., Wiese, R.A., and Zubriski, J.C.
Minnesota University, Department of Soil Science, Minneapolis, Minnesota 55455.
Crops and Soils Magazine, Vol. 29, No. 7, p 14-21, April-May, 1977. 5 fig.

Descriptors: Nitrogen, Nutrients, Fertilizers, Fertilization, Rainfall, Soil water, Soil moisture, Economics.

Various experiments of irrigation-fertilization are presented by five authoritative authors. The fertilization time frame and injection of fertilizers in irrigation water and the economics of fertilization are considered.

77:03F-110
OUR NEWEST NATURAL RESOURCE--COMPACTION--GOOD AND BAD EFFECTS ON ENERGY NEEDS,
Voorhees, W.B., and Hendrick, J.G.
United States Department of Agriculture, Agricultural Research Service, Morris, Minnesota.
Crops and Soils Magazine, Vol. 29, No. 7, p 11-13, April-May, 1977. 1 fig.

Descriptors: Soil properties, Soil compaction, Soil density, Soil erosion, Runoff, Soil management, Soil structure, Soil physical properties, Bulk density, Crop production.

Soil compaction caused by wheel traffic during normal farming operations can create serious soil erosion and water runoff problems, and can drastically restrict root growth and reduce crop yields.

77:03F-111
DEEP PLOWING, CURE FOR SODIC CLAYPAN,
Sandoval, F.M., and Jacober, F.C.
United States Department of Agriculture, Agricultural Research Service, Mandan, North Dakota.
Crops and Soils Magazine, Vol. 29, No. 7, p 9-10, April-May, 1977. 1 fig.

Descriptors: Soil investigations, Soil tests, Soil types, Soil treatment, Soil structure, Soil profiles.

Sodic claypan soils are not desirable. More common names for this type of soil are scabland, scabspot land, or panspot land. How common are these soils? We have about 17 million acres in the Northern Great Plains. There are another 12 million acres to the north in the Canadian prairie provinces.

77:03F-112
SUGAR BEET RESPONSE TO WATER STRESS IN SANDY SOILS,
Stegman, E.C., and Bauer, A.
North Dakota State University, Department of Agricultural Engineering, Fargo, North Dakota.
Transactions of the American Society of Agricultural Engineers, Special Edition, Vol. 20SW, p 469-473, 477, June 20, 1977. 12 fig, 1 tab, 13 ref, 1 equ.

Descriptors: Sugar beets, Plant growth, Crop response, Crop production, Soil water, Irrigation effects, Soil moisture, Leaves.

Leaf xylem pressure data suggest brief reductions to about -14 to -15 bars may be tolerable provided average pressure over 10-20 day intervals is above -12 bars. Seasonal average pressures of -15 and -21 bars were found to reduce yields to 0.6 and 0.1 that of a nonstress treatment, respectively. Water management criteria based upon allowable levels of leaf xylem pressure are suggested.

77:03F-113
CALCULATING THE COST OF EACH IRRIGATION,
New, L.
Texas A and M University, Texas A and M Research Center, Lubbock, Texas.
Irrigation Age, Vol. 11, No. 9, p 56-57, July-August, 1977. 2 tab.

Descriptors: Irrigation, Irrigation practices, Irrigation efficiency, Pumping, Economics.

In view of today's energy costs, excessive irrigation amounts and poor field distribution patterns can seriously damage the profitability of a farming enterprise. You may have a good idea of your total pumping time, and your annual fuel costs per acre of land. But the best lead to your irrigation efficiency is to know how much water is pumped, and where it's going. You can obtain those figures by knowing your irrigation well capacity and the number of hours that a well or group of wells are pumped to irrigate a specific acreage. The specific acreage can be an irrigation set, a section of land, a field of corn, or even the actual acreage irrigated by a center pivot sprinkler.

77:03F-114
DRIP IRRIGATION STRIKES BACK AT WATER SHORTAGES,
Davis, S.
California University, Department of Agricultural Engineering, Riverside, California.
Irrigation Age, Vol. 11, No. 9, p 31, 35, July-August, 1977.

Descriptors: Irrigation, Irrigation systems, Irrigation practices, Water conservation.

To solve the drought problem facing us in 1977, or during any dry year, we must learn to store more water and make more use of our available water. One efficient way to accomplish the latter is with drip irrigation.

77:03F-115
SUGAR BEETS TOLERATE MORE LIMITED IRRIGATION,
New, L.
Texas A and M University, Texas A and M Research Center, Lubbock, Texas.
Irrigation Age, Vol. 12, No. 1, p 51-52, September 1977. 2 fig, 1 tab.

Descriptors: Sugar beets, Irrigation, Irrigation effects, Irrigation practices, Water conservation, Evapotranspiration.

Sugar beets, once considered to have high and critical demands for water, have yielded well under more limiting irrigation in field tests near Hereford, Texas. In 5-year irrigation demonstrations, sugar beets that were irrigated on 3-week intervals averaged 27.3 tons per acre, while beets that were irrigated on 2-week intervals averaged 26.7 tons. Irrigation applications averaged about 8 inches less when irrigating on the 3-week frequency. In a third comparison, sugar beets irrigated on 4-week intervals averaged 24.3 tons per acre.

77:03F-116
CONTROLLING SEDIMENT IN SURFACE RUNOFF,
Humpherys, A.
Snake River Conservation Research Center, Agricultural Engineering Division, Kimberly, Idaho.
Irrigation Age, Vol. 12, No. 1, p 22, 24, September 1977. 1 fig.

Descriptors: Sediments, Nutrients, Runoff, Irrigation, Irrigation effects, Pesticides, Fertilizers, Salts.

Irrigators are sometimes criticized for contaminating downstream waters with sediment, nutrients and pesticides contained in surface runoff from irrigation. Research studies have shown that the concentrations of dissolved fertilizer nutrients, pesticides and salts in surface runoff are essentially the same as those in the applied irrigation water. Thus, water passing over the soil surface does not usually pick up additional amounts of these materials. Significant increases in nutrient or pesticide concentration do occur when these materials are applied by adding them to the irrigation water or when the material falls into the water from spray applications or washed from the plants by rain. When fertigation and herbigation are practiced, runoff water should be retained in a reuse pond and not allowed to leave the farm or flow into natural streams.

77:03F-117
MONITORING SAVES MONEY AND WATER,
Ruen, J.
Irrigation Age, Vol. 12, No. 1, p 16, 19, September 1977. 2 fig.

Descriptors: Irrigation efficiency, Crop production, Nebraska, Scheduling, Water conservation.

Cut energy costs, increase water efficiency, boost yields. And, save money and water at the same time. Sound impossible? Nebraska farmers are doing it with irrigation scheduling and a little help from their friends.

77:03F-118
HOW THEY'RE HARNESSING THE SUN TO PUMP WATER,
Larsen, R.
Irrigation Age Magazine.
Irrigation Age, Vol. 12, No. 2, p 6-8, October 1977. 4 fig.

Descriptors: Irrigation, Irrigation practices, Irrigation systems, Solar radiation.

Natives worshipped it; sunbathers sought it, and farmers welcomed it. Despite all this attention given to the sun, serious efforts to harness the sun's rays for energy have been few. Now there is a major attempt by private firms and government agencies to find a way of using sunlight to power the nation's irrigational systems.

77:03F-119
IRRIGATION AND WILDLIFE: CAN THEY BE COMPATIBLE?
Nelson, M.J.
Irrigation Age, Vol. 12, No. 3, p 8-9, 16, November-December, 1977. 5 fig.

Descriptors: Wildlife, Wildlife habitats, Irrigation, Irrigation effects, Wildlife management.

Irrigation and wildlife would seem to be mutually exclusive. Bulldozing trees to accomodate center pivot systems, the tendency toward monoculture encouraged by the big systems, and the elimination of fencerows and traditional field edges are an anathema to wildlife. To listen to the voices of gloom and doom complaining about the loss of habitat in the country, it would seem that irrigation is in large part responsible for the decline of the pheasant, the quail, the deer, and the whooping cranes. They would have you believe that it is possible to have irrigated crops in an area, or produce wildlife, but not both. However, the picture is not that bleak, not at all, in fact. With small, seemingly insignificant changes in farming practices, irrigation can be greatly beneficial to wildlife, even in areas where it is heavily developed.

77:03F-120
MAKING THE DESERT FLOWER: IRRIGATING CALIFORNIA'S IMPERIAL VALLEY,
Mallory, R.
Irrigation Journal, Vol. 27, No. 5, p 19-20, 27, September-October, 1977. 2 fig.

Descriptors: California, Water conservation, Water quality, Crop production, Salinity, Saline soils, Furrow irrigation.

"Making the desert flower" is a description heard many times in the irrigated farmlands of the West. But perhaps nowhere is the description more appropriate than in California's Imperial Valley. With less than three inches of rain per year in this southern-most California valley, the land could not even be initiated into dryland wheat production as was much of the rest of the state.

77:03F-121
DRIP STUDY SHOWS UP TO 30% WATER SAVINGS,
Schleicher, J.
Irrigation Age, Vol. 11, No. 4, p 37, 69, January 1977. 1 fig.

Descriptors: Irrigation, Irrigation practices, Irrigation systems, Irrigation efficiency, Orchards, Crop production, Water conservation.

Tree crop farmers repeatedly hear how efficient drip irrigation is in relation to either sprinkler or furrow water application methods. But just how does "drip efficiency" stack up in terms of comparative water savings with sprinkler and furrow techniques? That question is the subject of a joint research project currently being sponsored by the University of California and the California Department of Water Resources on a citrus farm near Parlier, California. The study centers around a 40-acre block of 8-year-old Navel oranges, chosen for the uniformity of soil, water and tree conditions. The acreage is divided into 12 five-row blocks, permitting the researchers to create four replications each of the three irrigation methods.

77:03F-122
DRIP IRRIGATION AT SUPERIOR FARMING: WATER USE CUT 30%, FERTILIZER 50% BY THIS LARGE CORPORATE FARM,
Mallory, R.
Irrigation Journal.
Irrigation Journal, Vol. 27, No. 3, p 20-21, May-June, 1977. 5 fig.

Descriptors: Irrigation, Irrigation practices, Irrigation systems, Irrigation efficiency, Water conservation.

Superior Farming Company, which first started its drip irrigation experiments in 1971, had its 8,000 acres of trees and vines under drip by 1975--20 percent of the total drip irrigated acreage in California at the time.

77:03F-123
DEAD LEVEL FIELDS SIMPLIFY AUTOMATING IRRIGATION: ARS EXPERIMENTS IN ARIZONA,
Irrigation Journal, Vol. 27, No. 5, p 16, 25, September-October, 1977. 1 fig.

Descriptors: Irrigation, Irrigation efficiency, Crop production, Automation, Flood irrigation, Furrow irrigation.

Irrigators in the Southwest are increasingly taking part in a trend that promises to improve irrigation efficiency, raise crop production, and simplify automating water distribution systems. That trend is to level cropland to zero grade--dead level.

77:03F-124
3-WHEELED "MOSQUITO" IRRIGATES FROM DITCH,
White, J.
Denver, Colorado.
Irrigation Age, Vol. 11, No. 7, p 80-81, 86, April 1977. 2 fig.

Descriptors: Irrigation, Irrigation systems, Irrigation practices, Irrigation efficiency.

A farmer has designed a self-propelled irrigation "tractor" that looks amazingly similar to a mechanical mosquito. The "Mosquito" combines the advantages of circular pivot irrigation systems with the low cost of gravity irrigation. This new machine has helped increase yields on corn, wheat, barley and lettuce, the primary crops in the San Luis Valley in Southern Colorado, because the "Mosquito" provides more efficient use of water. The "Mosquito" also requires less supervision than some other irrigation systems, and produces higher yields and better water efficiency.

77:03F-125
AUTOMATION ASSURES PRECISE DELIVERY, CUTS LABOR,
Irrigation Age, Vol. 11, No. 8, p 31-32, May-June, 1977. 1 fig.

Descriptors: Automation, Irrigation, Irrigation systems, Irrigation practices, Irrigation efficiency, Arizona.

A study was undertaken in the Wellton-Mohawk Valley area to utilize automation to two common methods of turning water into a field--jack-gates and tile outlets. Farmers who grow wheat, alfalfa or cotton in the Wellton-Mohawk Valley operate on fairly tight soils, either clay loams or silty clay loams. Fields are generally dead-leveled (level basins) and the types of outlets discussed, jack-gates and tile outlets, were used. It was determined that both types of systems could be successfully automated. However, thus far, jack-gates have proved more effective.

77:03F-126
CORN AND ALFALFA PRODUCTION AS INFLUENCED BY IRRIGATION AND SALINITY,
Hanks, R.J., Sullivan, T.E., and Hunsaker, V.E.
Utah State University, Logan, Utah.
Soil Science Society of America Journal, Vol. 41, No. 3, p 606-610, May-June, 1977.
5 fig, 6 tab, 9 ref.

Descriptors: Corn, Alfalfa, Crop response, Salinity, Soil moisture, Irrigation effects, Evapotranspiration, Crop production.

Yields of corn and alfalfa were determined where both salinity and water stress were imposed. Yields of corn at Logan, Utah in 1975 were decreased by salinity or water stress (caused by low irrigation levels) in direct relation to the decrease in evapotranspiration. The decrease in evapotranspiration was caused by a decrease in soil water depletion, indicating that salinity influenced soil water availability. Corn yields at Vernal, Utah in 1974 were decreased by salinity, but to a considerably lesser extent by low irrigation, probably because of water flow upward into the root zone from a water table. Alfalfa yields at Vernal in 1974 were not decreased by salinity or by low irrigation rates, because of water supplied by a water table and used by roots below the zone of salinity.

77:03F-127
SOURCES, RATES, AND FREQUENCIES OF N APPLICATION IN SUBIRRIGATED HAY MEADOWS,
Daigger, L.A., and Moline, W.J.
Nebraska University, Department of Agronomy, Lincoln, Nebraska.
Agronomy Journal, Vol. 69, No. 4, p 644-647, July-August, 1977. 4 fig, 2 tab, 10 ref.

Descriptors: Subsurface irrigation, Irrigation systems, Nitrogen, Fertilizers, Fertilization, Nutrients, Soil investigations, Urea.

Inadequate supplies of soil nutrients often limits hay production of western United States subirrigated meadows. Our purpose was to evaluate the effectiveness of three N-sources at various rates in alternating sequences of N-applied annually, biennially, and triennially for meadow hay production.

77:03F-128
MEASURING THE AMOUNTS OF CROP RESIDUE REMAINING AFTER TILLAGE,
Sloneker, L.L., and Moldenhauer, W.C.
United States Department of Agriculture, Agricultural Research Service, Morris, Minnesota 56261.
Journal of Soil and Water Conservation, Vol. 32, No. 5, p 231-236, September-October, 1977. 6 fig, 5 tab, 10 ref.

Descriptors: Mulching, Crop production, Organic matter, Soils, Soil investigations, Tillage.

A simple method of estimating percent residue cover, and how to convert percent residue cover to tons per acre was devised. Under certain conditions, more than one fall mulch tillage operation can be performed without losing a large percentage of residue cover. We also determined the percentage of cover remaining after row-crop planting using various tillage methods on different soils at three locations.

77:03F-129
CHARACTERIZATION OF YIELD AND ECONOMIC LOSS FROM NONUNIFORM FERTILIZER DISTRIBUTION USING COMPUTER SIMULATION,
Sorenson, R.C., and Wiese, R.A.
Nebraska Agricultural Experiment Station, Lincoln, Nebraska 68583.
Soil Science Society of America Journal, Vol. 41, No. 2, p 382-385, March-April, 1977. 4 fig, 2 tab, 10 ref.

Descriptors: Model studies, Simulation analysis, Computer programs, Fertilizers, Fertilization, Nutrients, Crop production.

A simpler computer program has been developed to predict yield losses from uneven broadcast fertilizer distribution on the basis of distribution pattern, yield response curve, fertilizer rate, soil test rating and amount of fertilizer swath overlap. Losses were serious only on soils classed "very low" in nutrient supply. Losses for a highly responsive crop are less than for a less responsive crop. Overlapping succeeding swaths may improve the appearance of a field, but has a small effect on yield loss unless the amount of overlap is <50%. Visually evident streaks in plant growth patterns may not necessarily indicate high yield loss.

77:03F-130
THE FINE ART OF USING ENOUGH, BUT NOT TOO MUCH BORON,
Bowen, J.E.
Hawaii University, Department of Plant Physiology, Honolulu, Hawaii.
Crops and Soils Magazine, Vol. 29, No. 9, p 12-14, August-September, 1977. 2 fig, 1 tab.

Descriptors: Boron, Nutrients, Fertilizers, Fertilization, Crop production, Crop response.

During the past 50 years several seemingly different diseases have appeared in different crops. These diseases were puzzlers to both farmers and agricultural researchers. It has now been determined that all of these diseases are actually caused by the same problem; a lack of boron.

77:03F-131
LONG-TERM STRATEGIES FOR SUPPLYING NITROGEN TO CROPS,
Gutschick, V.P.
California University, Los Alamos Scientific Laboratory, Los Alamos, New Mexico 87545.

United States Energy Research and Development Administration, Publication No. LA-6700-MS, May 1977. 73 p, 136 ref, 3 append.

Descriptors: Nitrogen, Fertilizers, Fertilization, Crop production.

Raising food for present population requires nitrogenous fertilizers in addition to indirect management of the biosphere's nitrogen cycle. The Haber process for making the ammonia base of fertilizers is increasingly pressed by shortages of energy, while only minor improvements are still possible. The Haber process and 15 alternatives for increasing the nitrogen available to crops using less fossil energy is discussed. These alternatives span technology of fertilizer synthesis, farm management and technology, crop genetics, and market management.

77:03F-132
AGRONOMY ABSTRACTS, 1977 ANNUAL MEETINGS,
American Society of Agronomy
American Society of Agronomy, 677 South Segoe Road, Madison, Wisconsin 53711.
Agronomy Abstracts, Los Angeles, California, November 13-18, 1977. 198 p.

Descriptors: Model studies, Fertilization, Land use, Climatology, Environmental quality, Crop production, Soil chemistry, Nutrients, Soil, Soil water, Fertilizers, Soil physics.

This booklet contains the abstracts of each paper that was presented at the 1977 Annual Meetings of American Society of Agronomy, Crop Science Society of America, and Soil Science Society of America.

77:03F-133
MORE GROWERS TURN TO HERBIGATION FOR WEED CONTROL,
Irrigation Age, Vol. 11, No. 4, p 47-48, January 1977. 2 fig, 1 tab.

Descriptors: Herbigation, Weed control, Herbicides, Irrigation, Irrigation practices, Chemicals.

The beneficial effects of herbigation are described and equipment to accomplish herbigation.

77:03F-134
THE BRIGHT SIDE OF LOW PRESSURE,
Irrigation Age, Vol. 11, No. 4, p 52, January 1977. 1 fig.

Descriptors: Sprinkler irrigation, Irrigation, Energy, Economics, Sprinklers.

The benefits of low pressure nozzles for sprinkler irrigation are described.

77:03F-135
POLICY OF PRICING IRRIGATION WATER,
Jain, J.K.
Ministry of Agriculture and Irrigation, New Delhi (India).
ICID Bulletin, Vol. 26, No. 1, p 41-49, January 1977. 2 tab, 14 ref.

Descriptors: *Pricing, *Water policy, *Irrigation, *Water rates, Economics, Governments, Cost-benefit analysis, Economic developments, Economic impact, Political constraints, Subsidization, Crop production, Agriculture, Water management (applied), Cost repayment.

Based on analysis of irrigation water pricing issues and theory, a guideline is suggested for formulating governmental pricing policy and its application is described for India. Major aspects are: (1) Subsidies up to 50% may encourage irrigation use and minimize inflation in the initial stages of irrigation development. (2) Assessment may be based on crop area in the interests of practicality and convenience but volumetric pricing should be promoted wherever possible, especially on tube wells. (3) In areas where farmers are not yet accustomed to irrigation, a two-part tariff may be introduced in place of the simpler single charge based on crop area. (4) Irrigation rates should be uniform unless there are strong reasons to introduce variable rates, such as variations in climate, soil, irrigation systems, crop irrigation requirements, or utilization of irrigation potential. Preindependence Indian pricing policy was based on strict adherence to financial return, but since 1947 this criterion was initially relaxed and subsequently replaced by a cost-benefit standard in order to achieve rapid development of irrigation. The result was very low water rates, heavy government subsidization, and considerable diversity in the fixing of rates. Recent trends on pricing are reviewed, with attention to quantum of water rates, mode of assessment, water rate structure, and water rate uniformity/diversity.

77:03F-136
COMPUTER MODELING TO MAXIMIZE WATER USE EFFICIENCY AND REDUCE ENERGY IN IRRIGATION,
Gilley, J.R.
Nebraska University, Water Resources Center, 310 Agricultural Hall, Lincoln, Nebraska 68583.
Project Completion Report A-038-NEB, 30 p, 10 fig, 9 ref.

Descriptors: Irrigation systems, Energy, Soil-water-plant relationships, Soil moisture, Water conservation, Model studies, Mathematical models, Crop production, Computer models.

A simplified irrigation scheduling model, IRRIGATE, has been developed as an educational tool for use by University personnel and in extension programs. Irrigations are scheduled using the basic premise of maximizing yields with a minimum of applied irrigation water. Use of IRRIGATE has grown rapidly in Nebraska and in addition to being used as an educational tool it was also used by private individuals, private irrigation scheduling companies, irrigation districts and others to schedule irrigations for approximately 25,000 acres during the 1977 season. A mathematical model, CORNGRO, has been developed to predict daily crop water use, plant growth, and crop yield for corn. CORNGRO has the capability of predicting corn yield as a result of different irrigation timing and amounts. The model can be useful in evaluating irrigation scheduling procedures in terms of yield, water conservation, energy conservation, production costs, and analyzing alternate levels of water applied. Tests of the model using data available from Mead, Nebraska indicate the model has considerable predictive power, although not all of the dynamics of crop growth are modeled in precise detail.

SECTION XV

WATER QUANTITY MANAGEMENT AND CONTROL

CONTROL OF WATER ON THE SURFACE (GROUP 04A)

77:04A-001
LINKED MODELS FOR MANAGING RIVER BASIN SALT BALANCE,
Helweg, O.J., and Labadie, J.W.
California University, Department of Civil Engineering, Davis, California.
Water Resources Research, Vol. 13, No. 2, p 329-336, April 1977. 6 fig, 8 ref.

Descriptors: *River basins, *Salt balance, *Optimization, *Simulation analysis, *Economic efficiency, *Water quality control, Management, Groundwater, Surface waters, Streams, Aquifers, Downstream, Wells, Pumping, Irrigation, Demand, Algorithms, Conjunctive use, Decision making, Equations.

A pressing problem facing the irrigation intensive areas of the world is the increasing salinity of groundwater. A cost-effective salinity management technique, called the accelerated salt transport (Astran) method, has been developed which may be feasible for many stream aquifer systems. The basic idea is to encourage application of pumped water downstream of the well from which it is pumped rather than within its vicinity. In this way a mechanism is established for accelerating the downstream transport of salts in the groundwater at a more rapid rate than would occur naturally through convection and dispersion while still satisfying irrigation demands. A management algorithm is developed for implementing the Astran method which combines an optimizing model with a detailed quantity-quality simulation model. The optimizing model generates least-cost alternatives for distributing water over the basin. These alternatives are subsequently examined by the simulation model as to their effectiveness in controlling the salt balance. A parameter in the optimizing model can be adjusted so as to produce a desired degree of salinity control. The management algorithm has been applied to the Bonsall Subbasin in the San Luis Rey River Basin in order to test its effectiveness. Results of the case study indicate that the Astran method: (1) is cost-effective, requiring roughly 10% of the cost of tiling for this area; (2) encourages balanced conjunctive use of surface water and groundwater; and (3) is flexible enough to respond to future management needs.

77:04A-002
FIELD EVALUATION OF SPRINKLER IRRIGATION FOR MANAGEMENT OF IRRIGATION RETURN FLOW,
Willardson, L.S., and Hanks, R.J.
Utah State University, Department of Agricultural and Irrigation Engineering, Logan, Utah.
Proceedings of National Conference on Irrigation Return Flow Quality Management, Colorado State University, Fort Collins, Colorado, p 109-114, May 16-19, 1977.
6 fig, 2 tab, 4 ref.

Descriptors: Salinity, Saline soils, Saline water, Irrigation, Utah, Leaching.

Sprinkler irrigation offers one alternative for control of irrigation water application that influences quality of return flow. A two-year field scale study of soil solution response to controlled water application using sprinklers was conducted in the Ashley Valley near Vernal, Utah. The design level of water control was attained with high coefficients of uniformity but the soil solution did not respond as expected. The soil acted both as a source and a sink for salt. Root zone salinity was only slightly affected by different leaching fractions. Minimum average leaching fractions obtainable are influenced by both the hydraulic design and operation of the system.

77:04A-003

EFFECTS OF IRRIGATION MANAGEMENT ON SOIL SALINITY AND RETURN FLOW QUALITY,

Wierenga, P.J., and Sisson, J.B.
New Mexico State University, College of Agriculture and Home Economics,
Department of Agronomy, Las Cruces, New Mexico.
Proceedings of National Conference on Irrigation Return Flow Quality Management,
Colorado State University, Fort Collins, Colorado, p 115-121, May 16-19, 1977.
3 fig, 3 tab, 12 ref.

Descriptors: Saline soils, Irrigation systems, Surface irrigation, Water quality, Groundwater, Irrigation efficiency, Soil water.

A field plot study was conducted to determine the effects of controlled surface irrigation and trickle irrigation on soil salinity, and on the quality and quantity of irrigation return flow. Changes in soil salinity were determined by taking extensive soil samples at least once a year. Return flow quality was measured on soil solution removed through vacuum samplers in the subsoil of each plot, and by analyzing the water quality at various levels below the groundwater and in a nearby drain. The quantity of return flow was estimated from crop growth and weather data, and amounts of water applied. This method was found more reliable than several other methods used for determining percolation losses. Results of the first three years of this ongoing study showed that a larger change in soil salinity was produced by altering irrigation frequency than by changing irrigation efficiency. Irrigating when 50 percent of the soil water had been depleted was the irrigation frequency most conducive to salt retention in the upper soil profile. However, different irrigation efficiencies and frequencies had no significant effect on cotton yield due in part to the large spatial variability of the physical properties of the soil at the site.

77:04A-004

EFFECT OF IRRIGATION SYSTEMS ON WATER USE EFFICIENCY AND SOIL WATER SOLUTE CONCENTRATIONS,

Wendt, C.W., Onken, A.B., Wilke, O.C., Hargrove, R., and Bausch, W.
Texas Agricultural Experiment Station, Lubbock, Texas.
Proceedings of National Conference on Irrigation Return Flow Quality Management,
Colorado State University, Fort Collins, Colorado, p 123-131, May 16-19, 1977.
9 tab, 8 ref.

Descriptors: Subsurface irrigation, Irrigation efficiency, Sprinkler irrigation, Furrow irrigation, Texas, Irrigation water, Return flow.

The effect of spinkler irrigation (Sp), furrow irrigation (F), subirrigation (Su), and automated subirrigation (ASu) systems on water use efficiency and soil water solute concentration was evaluated at a field site in Knox County, Texas. Significant differences existed in the irrigation water requirement of sweet corn irrigated by the different systems (F > Sp approximately = Su > ASu). However, little difference in total water requirement existed between systems -- the soil water was utilized more efficiently (ASu > Su approximately = Sp > F). Automation of irrigation systems offers the possibility of significantly enhancing irrigation water use efficiency of supplemental irrigated areas. Soil water solute concentrations were too low to be of concern relative to degrading the quality of irrigation return flow due to the dilution effect of rainfall. In most cases, at depths below 3.0 m, the concentrations of the above solutes in the soil were less than those of the irrigation water. Although soil water solutes were not a problem in the irrigation return flows, the lower concentrations of the ASu and Su systems indicate that they may be superior to F and Sp systems in maintaining the quality of irrigation return flows where solutes are a problem.

77:04A-005

AN ECONOMIC ANALYSIS OF IRRIGATION RETURN FLOW RECYCLE SYSTEMS IN THE CENTRAL VALLEY OF CALIFORNIA,

Kinney, W., Horner, G.L., and Tanji, K.K.
California University, Department of Agricultural Economics, Davis, California.
Proceedings of National Conference on Irrigation Return Flow Quality Management,
Colorado State University, Fort Collins, Colorado, p 175-182, May 16-19, 1977.
2 tab, 6 ref, 1 append.

Descriptors: Recycling, Irrigation districts, Return flow.

Irrigation return flow recycle systems have been used in California for a number of years under a variety of crop rotations, soil characteristics and qualities of irrigation water. Recycle systems operating on the field, farm and district level were compared on the basis of cost in two areas of the San Joaquin Valley. The effects of three scales of recycle systems on the least-cost combination of irrigation water delivery systems and water management techniques were evaluated.

77:04A-006
ON-FARM METHODS FOR CONTROLLING SEDIMENT AND NUTRIENT LOSSES,
Fitzsimmons, D.W., Brockway, C.E., Busch, J.R., Lewis, G.C., and McMaster, G.M.
Idaho University, Department of Agricultural Engineering, Moscow, Idaho.
Proceedings of National Conference on Irrigation Return Flow Quality Management, Colorado State University, Fort Collins, Colorado, p 183-191, May 16-19, 1977.
2 fig, 12 tab, 6 ref.

Descriptors: Sediments, Nutrients, Idaho, Irrigation, Irrigation water, Runoff, Return flow, Sediment yield, Beans, Phosphates, Irrigation practices.

Field experiments were conducted in the Boise and Magic Valley areas of southern Idaho during the 1975 and 1976 irrigation seasons to evaluate on-farm methods for controlling sediment and nutrient losses from irrigated fields. In one experiment, four 1.7 ha plots of field corn were continuously monitored during the two irrigation seasons. Varying furrow stream sizes and stream cutback methods were used to apply the same total amounts of irrigation water to three of the plots. No control measures were used on the fourth plot. Runoff from two of the first three plots were run through a vegetated buffer strip at the lower end of the field and then a settling basin. Runoff from the other two plots were run through a basin only. The effects of each treatment and control measure on the quality and quantity of return flow from these plots are presented. The results of sediment and nutrient yield determinations on several other field sites in the two study areas are also presented. The effects of various combinations of soil types, crops, irrigation practices and sediment retention devices on sediment and nutrient losses from these sites were evaluated.

77:04A-007
WATER DISTRIBUTION PATTERNS FOR SPRINKLER AND SURFACE IRRIGATION SYSTEMS,
Karmeli, D.
Colorado State University, Department of Agricultural and Chemical Engineering, Fort Collins, Colorado.
Proceedings of National Conference on Irrigation Return Flow Quality Management, Colorado State University, Fort Collins, Colorado, p 233-251, May 16-19, 1977.
11 fig, 4 tab, 19 ref, 26 equ.

Descriptors: Model studies, Simulation analysis, Sprinkler irrigation, Irrigation efficiency.

A linear fit model for sprinkler and power curve fit model for surface irrigation systems, are suggested to represent actual patterns of distributions in irrigated fields. Both models allow for efficient calculation of surplus and deficient volumes, as well as the various relevant efficiencies. Both environmental and economical aspects require desired efficiency combinations to be followed,and this may be done when the irrigation systems are represented by the suggested models. Also, the various functions related to irrigation performance, may be integrated to reach optimal results.

77:04A-008
APPLICATION OF MODERN IRRIGATION TECHNOLOGY IN THE MESILLA VALLEY, NEW MEXICO,
Sammis, T.W., and Hohn, C.M.
New Mexico State University, Department of Agricultural Engineering, Las Cruces, New Mexico.
Proceedings of National Conference on Irrigation Return Flow Quality Management, Colorado State University, Fort Collins, Colorado, p 269-276, May 16-19, 1977.
2 fig, 4 tab, 3 ref.

Descriptors: Irrigation systems, Surface irrigation, Irrigation efficiency, Saline soils, Rio Grande River, Return flow, Irrigation, Orchards, Alfalfa, Root zone.

Current engineering technology is being applied to a Demonstration Farm in the Mesilla Valley, New Mexico to demonstrate the feasibility of decreasing the large amount of salt returned to the Rio Grande River System through return flow drainage. The reduction in return flow is accomplished by irrigation scheduling techniques and more efficient irrigation methods, such as drip irrigation. A small pecan orchard has been converted from flood irrigation to drip irrigation resulting in the water application reduction greater than 50 percent with a marked visible increase in growth rate over that of the previous year. Irrigation scheduling increased the efficiency of irrigation timing on the farm resulted in an improved soil condition, in some cases one less irrigation. Monitoring of the applied water on the Demonstration Farm resulted in estimates of irrigation efficiencies for the season ranging from 54 percent for wheat to 97 percent for alfalfa. The high efficiency for alfalfa was probably due to the high water table which contributed water to the crops in addition to the applied water. Monitoring of the soil salinity is enabling the investigators to follow the movement and buildup of salt below the root zone with increased irrigation efficiencies. Information gained from the Demonstration Farm is being used by the Cooperative Extension Service in an educational program. The various methods used to make the public aware of EPA's efforts on the Demonstration Farm include media releases, tour brochures, and field days.

77:04A-009
ECONOMICS OF CONTROLLING IRRIGATION RETURN FLOW IN THE MESILLA VALLEY, NEW MEXICO,
Lansford, R.R., Gelhar, L.W., and Creel, B.J.
New Mexico State University, Las Cruces, New Mexico.
Proceedings of National Conference on Irrigation Return Flow Quality Management, Colorado State University, Fort Collins, Colorado, p 277-282, May 16-19, 1977.
4 fig, 1 tab, 6 ref.

Descriptors: Model studies, Water quality, Water management (Applied), Irrigation, Irrigation water, Return flow.

Preliminary budgeting indicates that net returns of water are reduced by incorporation of irrigation water management practices, but that irrigation water requirements may be reduced. Thus, incorporation of these improved irrigation water management practices may be feasible under restricted water availability constraints. If irrigation water use can be reduced without affecting the local agricultural economy by optimal crop selection incorporating the improved practices, the quantity of irrigation return flows may be reduced and possibly the quality may be improved. Further evaluation in the current and last year of the three-year project will provide opportunities for refinements and sensitivity evaluation in the linear programming model as well as more extensive iterative analysis with the hydrological model.

77:04A-010
WELLTON-MOHAWK ON-FARM SYSTEMS IMPROVEMENT PROGRAM,
Swenson, R.S.
United States Department of Agriculture, Soil Conservation Service, Phoenix, Arizona.
Proceedings of National Conference on Irrigation Return Flow Quality Management, Colorado State University, Fort Collins, Colorado, p 349-351, May 16-19, 1977.
1 tab, 2 ref.

Descriptors: Irrigation, Irrigation systems, Irrigation practices, Irrigation efficiency, Return flow.

The objective of the SCS in the Wellton-Mohawk Irrigation Improvement Program is to increase irrigation efficiency on farms in the district and thereby reduce return flows from the district. To accomplish this, the SCS enters into contracts with eligible landowners and operators to implement conservation practices that will further the program goals. Cost sharing is provided on a 75% federal, 25% cooperator basis.

77:04A-011

THE USE OF LONG-THROATED FLUMES TO MEASURE FLOWS IN IRRIGATION AND DRAINAGE CANALS,
Bos, M.G.
International Institute for Land Reclamation and Improvement, Wagenengin, The Netherlands.
Agricultural Water Management, Vol. 1, No. 2, p 111-126, September 1977. 7 fig, 2 tab, 9 ref, 20 equ, 1 append.

Descriptors: Water measure, Flow measurement, Measurement, Flumes, Flow rates, Hydraulic, Irrigation water, Weirs.

Presented in this paper is a set of easy-to-use formulae that give an accurate head-discharge relationship for long-throated flumes with a prismatic throat cross-section. The method by which the formulae have been derived is the same for all long-throated flumes, regardless of the shape of their throat cross-sections. As a result, the value of the discharge coefficient is independent of this shape and is a function of the ratio of the upstream energy head over the flume to the flow-wise length of the throat. The formulae and coefficient values in this paper also apply to broad-crested weirs with rounded upstream nose.

77:04A-012
BIBLIOGRAPHY ON DISCHARGE MEASUREMENT TECHNIQUES,
The Task Committee on Flow Measurement of the Committee on Hydraulic Structures of the Hydraulics Division,
American Society of Civil Engineers, New York, New York.
Journal of the Hydraulics Division, American Society of Civil Engineers, Vol. 103, No. HY8, p 889-903, August 1977.

Descriptors: Flow measurement, Bibliographies, Discharge measurement, Flow rates, Irrigation, Irrigation efficiency.

The Task Committee on Discharge Measurement was authorized by the Hydraulics Division in August 1968. The Task Committee's charge relative to flow measurement included a review of techniques available, the encouragement of research in flow measurement, and the preparation of a final report. A review of the literature was made, resulting in the substantial bibliography which constitutes this report.

77:04A-013
DESIGN OF IRRIGATION PIPE LATERALS WITH MULTIPLE OUTLETS,
Perold, R.P.
Division of Agricultural Engineering, Department of Agricultural Technical Services, Stellonbosch, Republic of South Africa.
Journal of the Irrigation and Drainage Division, American Society of Civil Engineers, Vol. 103, No. IR2, p 179-195, June 1977. 8 fig, 9 ref.

Descriptors: Irrigation, Irrigation systems, Irrigation design, Irrigation engineering, Hydraulics, Hydraulic design.

Design criteria for the design of multiple outlet irrigation pipe laterals are examined and the mean deviation is recommended as the criterion. The problem of the sloping pipe lateral design (constant diameter) can be solved precisely by computing a series of dimensionless solutions and calculating the mean deviation in each case, as well as the design parameters, Rs, and Hs, which state the relation between frictional losses and gradient differences, respectively, to the design outlet pressure. A design chart is presented from which the permissible number of outlets for a given value of the mean deviation can be read, or from which Rs can be read for a given number of outlets so that the pipe diameter can be found. Suitable programs for a pocket calculator are given so that the inlet pressure required for a particular case can be found. Programs are also given so that the final value of the mean deviation can be checked or the pressures at intermediate outlets determined.

77:04A-014
DESIGN OF DRIP IRRIGATION SUBMAIN,
Wu, I., and Gitlin, H.M.
Hawaii University, Department of Agricultural Engineering, Honolulu, Hawaii.
Journal of the Irrigation and Drainage Division, American Society of Civil Engineers, Vol. 103, No. IR2, p 231-243, June 1977. 9 fig, 4 ref.

Descriptors: Irrigation, Irrigation systems, Irrigation design, Hydraulics, Hydraulic design.

A submain is a part of a drip irrigation system. It is used as a control having the following functions: (1) To control irrigation application; (2) to sequentially irrigate separate fields; and (3) to reduce main line pressure to the lateral operating pressure. The design of submains is based on both capacity and uniformity. Capacity means that submain size should be designed to deliver the required amount of water to irrigate the field. Uniformity means that the submain should be designed to minimize pressure variation so the flow into all lateral lines will be nearly equal. The submain is hydraulically the same as lateral lines having a steady spatially varied flow with equally spaced lateral outflows. Design of the submain will be based on a study of hydraulics and energy relations. The design chart developed for laterals can also be used for submains, provided a set of charts is made for different possible submain sizes. This paper presents a general design chart that can be used for different submain sizes and a simplified submain chart that can be used to simplify and speed up design. Considerations are also made for irregularly shaped fields.

77:04A-015
SEEPAGE CHARACTERISTICS OF STABLE CHANNELS,
Gill, M.A.
Ahmadu Bello University, Department of Civil Engineering, Zaria, Nigeria.
Journal of the Irrigation and Drainage Division, American Society of Civil Engineers, Vol. 103, No. IR1, p 95-99, March 1977. 2 fig, 4 ref.

Descriptors: Seepage, Channels, Channel flow, Channel erosion, Channel improvement, Hydraulics.

Seepage characteristics of hydraulically stable channels are investigated using the method of Zhukovsky's function. It was found that a function of the form given in Equation 2 describes seepage characteristics of a channel whose shape is defined by a cosine curve. This shape conforms exactly to the shape of a hydraulically stable channel. Expressions for seepage discharge, streamlines, and equipotential lines are obtained, and results are demonstrated graphically for a channel in which H = 3, and B = 10 units of length.

77:04A-016
PULSE IRRIGATION--DESIGN FOR OPERATING SETS,
Karmeli, D., and Peri, G.
Colorado State University, Department of Agricultural Engineering, Fort Collins, Colorado.
Journal of the Irrigation and Drainage Division, Proceedings of the American Society of Civil Engineers, Vol. 103, No. IR1, p 33-41, March 1977. 1 fig, 3 tab, 1 ref.
(See 77:03F-021)

77:04A-017
ALGEBRAIC COMPUTATION OF FLOW IN BORDER IRRIGATION,
Strelkoff, T.
California University, Department of Water Science and Civil Engineering, Davis, California.
Journal of the Irrigation and Drainage Division, American Society of Civil Engineers, Vol. 103, No. IR3, p 357-377, September 1977. 10 fig, 6 ref.

Descriptors: Border irrigation, Surface irrigation, Model studies, Simulation analysis, Infiltration, Irrigation design.

The elements of a model of surface irrigation in a border have been presented. A sufficient number of physical assumptions have been made to allow the phenomena to be described by algebraic equations. This involves adaptation of simple shapes to both the surface and subsurface profiles. The absolute value of depth at key points in the surface profile is related to discharge through the assumption that the depth is normal. In the subsurface profile, the depth at key points is related to the time water has been available there for infiltration through an infiltration-time formula.

77:04A-018
BORDER-IRRIGATION HYDRAULICS WITH ZERO INERTIA,
Strelkoff, T., and Katopodes, N.D.
California University, Water Science and Engineering Section, Land, Air and Water Resources, Davis, California.
Journal of the Irrigation and Drainage Division, American Society of Civil Engineers, Vol. 103, No. IR3, p 325-342, September 1977. 7 fig, 19 ref.

Descriptors: Border irrigation, Surface irrigation, Irrigation, Irrigation practices, Irrigation systems, Irrigation engineering, Model studies.

A model of border irrigation based on the Saint-Venant equations with the acceleration (inertia) terms deleted has been constructed. For the test cases presented, agreement with more complex (and costly) models and with experiment has been satisfactory.

77:04A-019
HYDRODYNAMICS OF BORDER IRRIGATION--COMPLETE MODEL,
Katopodes, N.D., and Strelkoff, T.
California University, Department of Water Science and Engineering, Davis, California.
Journal of the Irrigation and Drainage Division, American Society of Civil Engineers, Vol. 103, No. IR3, p 309-324, September 1977. 5 fig, 1 tab, 6 ref.

Descriptors: Border irrigation, Irrigation, Irrigation practices, Irrigation systems, Model studies, Simulation analysis, Hydrodynamics, Irrigation engineering, Surface irrigation.

The phenomenon of surface irrigation from start to finish is modeled mathematically, using the method of characteristics. The solution, based on prescribed time increments, is correct to second-order accuracy, and the iterative scheme had second-order rate of convergence. The cost and accuracy of the model were tested against existing field data and other models. Approximately 400 FORTRAN statements are required for the complete code. The processing time on a Burroughs 6700 digital computer ranges from 3 minutes to 5 minutes for a complete irrigation. At $165/hr, this amounts to $10-$15 per run. The aim of this work was a complete hydrodynamic model that can be trusted and operated by anyone at moderate expense. It is not intended for design or specific applications.

77:04A-020
IMPLICATIONS OF IRRIGATION SYSTEM EFFICIENCIES,
Kruse, E.G., and Heerman, D.F.
United States Department of Agriculture, Agricultural Research Service, Fort Collins, Colorado 80523.
Journal of Soil and Water Conservation, Vol. 32, No. 6, p 265-270, November-December, 1977. 32 ref.

Descriptors: Irrigation, Irrigation efficiency, Irrigation water, Irrigation system, Irrigation engineering, Sprinkler irrigation, Surface irrigation, Furrow irrigation, Tailwater, Water quality, Water resources, Water shortage, Water supply, Water conservation.

Field or farm irrigation efficiencies vary greatly, depending on water supply, type of irrigation system, crop, soil, and especially the level of management provided by the irrigator. Sprinkler and trickle systems simplify some management decisions by virtue of their design, at the expense of higher capital costs.

Both generally have higher application efficiences than conventional surface systems. But surface irrigation using tailwater return facilities or level-basin concepts, may also be efficient. Irrigation efficiency is more important today than ever before because of limited supplies of water and energy. Irrigators must look closely at attainable efficiencies of new or improved irrigation systems if they are pumping water, if their seasonal water supplies are only marginally adequate for crop needs, or if water lost from their systems degrades water quality for downstream users. There are situations, however, where gravity flow provides adequate water, and the quality of surface and subsurface return flow equals that of the irrigation water supply. In these cases, use of water over an entire project or river basin is a more important consideration than irrigation efficiencies on individual farms.

77:04A-021
PERCEPTION OF ENVIRONMENTAL DAMAGE ASSOCIATED WITH IRRIGATION,
Jackson, R.H.
Brigham Young University, Department of Geography, Provo, Utah 84602.
Journal of Environmental Management, Vol. 5, No. 2, p 115-126, April 1977. 5 fig, 3 tab, 4 ref.

Descriptors: Irrigation, Irrigation practices, Irrigation effects, Salinity, Erosion, Water conservation, Environmental effects, Environmental control.

In order to determine the level of awareness of environmental damage associated with irrigation, questionnaires were administered to farmers and nonfarmers in Utah Valley, Utah. The results of the survey revealed that farmers seem to be more concerned about the damages from irrigation as determined by their voluntary responses to open-ended questions about irrigation damage. One-fourth of the farmers indicated they perceived some damage from irrigation, but only 10% of the nonfarmers so responded. When asked whether they were aware of specific damages, however, three times as many nonfarmers as farmers indicated awareness of such damage as erosion, alkalinity, waterlogging, and so forth. Farmer perception of destruction associated with irrigation increased only slightly when asked about specific types of damage. The level of awareness of damage for both groups was much lower than anticipated, indicating a lack of perception of damage. Several hypotheses are suggested to account for this low level of perception.

77:04A-022
FEASIBILITY OF INTERBASIN WATER TRANSFER,
Aron, G., White, E.L., and Coelen, S.P.
Pennsylvania State University, Department of Civil Engineering, University Park, Pennsylvania.
Water Resources Bulletin, Vol. 13, No. 5, p 1021-1034, October 1977. 5 fig, 1 tab, 15 ref.

Descriptors: *Inter-basin transfers, *Water resources, *Alternative planning, *Feasibility studies, *Water supply, *Flood protection, *Cost comparisons, *Reservoirs, Regional analysis, Economic feasibility, Hydrologic aspects, Flood control, Low-flow augmentation, River basins, Water storage, Benefits, Costs, Equations.

Interbasin water transfer is one of the most controversial water resources planning topics. Local communities, particularly those from which the water is to be taken (donor regions), generate enough opposition to doom many projects to failure. The opposition often arises because planners have traditionally considered excess water a free commodity rather than a marketable resource. To make transfer schemes mutually acceptable to donor and recipient regions, visible benefits must be offered. Agreement must be made on an acceptable purchase price and/or on other benefits such as a substantial amount of low flow augmentation or possibly some degree of flood control on the donor source stream. The hydrologic and economic feasibility of water transfer from the East Susquehanna River basin to the Delaware Reservoir System for supplemental supply to the New York City area has been investigated. Nine alternative schemes for diversions up to 400 cfs and compensations in the form of low flow augmentation and/or flood control were considered resulting in unit costs to the recipient region between $90 and $380/mg. If only the minimum state-mandated flow is released to the Susquehanna River, the savings to the water recipients would be sufficient to pay a purchase price of about $21/mg, which would be equivalent to a total amount of $420,000/year for an average export of 100 cfs.

77:04A-023

STEADY INFILTRATION FROM A DITCH: THEORY AND EXPERIMENT,

Batu, V.
Karadeniz Teknik University, Department of Civil Engineering and Architecture, Trabzon (Turkey).
Soil Science Society of America Journal, Vol. 41, No. 4, p 677-682, July-August, 1977. 8 fig, 12 ref.

Descriptors: *Infiltration, *Ditches, *Model studies, *Laboratory tests, Mathematical models, Hydraulic conductivity, Flow, Steady flow, Soil water, Soil water movement, Moisture content, Distribution patterns, Soil physics, Soil science.

The two-dimensional, steady-state water flow equation, which is based on the assumption that the hydraulic conductivity is an exponential function of the soil water pressure, was solved for a ditch on the soil surface. The results included expressions describing the distributions of matric flux potential and water content. Measured water contents were compared with this mathematical model and with other models.

77:04A-024

MAINLINE INSTALLATION,

Hamisch, F.
Ag Water, 22008 Riverside, Shafter, California 93263.
Drip/Trickle Irrigation, Vol. 2, No. 2, p 12, 30. 1 fig.

Descriptors: Irrigation systems, Irrigation practices, Irrigation design, Hydraulics, Pipes, Piping systems, Pipelines.

The mainline is an integral part of the drip irrigation system. In order for the installed pipeline to perform properly, it must be properly designed. The design of the pipeline has been previously discussed in the last issue and will not be covered here. The pipeline designated must be of the proper size with appropriate protection devices, such as pressure relief valves, vacuum relief valves, air release valves and check valves.

77:04A-025

EXPERIMENTAL EVALUATION OF THEORETICAL SOLUTIONS FOR SUBSURFACE DRAINAGE AND IRRIGATION,

Tang, Y.K., and Skaggs, R.W.
North Carolina State University, Department of Biological and Agricultural Engineering, Raleigh, North Carolina 27607.
Water Resources Research, Vol. 13, No. 6, p 957-965, December 1977. 12 fig, 3 tab, 23 ref, 15 equ.

Descriptors: Soil water, Soil water movement, Saturated flow, Drainage, Laboratory tests, Unsaturated flow, Hydraulic conductivity, Water table, Subsurface irrigation, Irrigation, Irrigation practices.

The Richards equation for two-dimensional saturated-unsaturated water movement was solved for drainage and subirrigation boundary conditions by using finite difference methods. The solutions were compared to results of experiments conducted for various initial and boundary conditions in a large laboratory soil tank. The soil water characteristic and hydraulic conductivity function were measured by conventional methods and used as inputs in the numerical solution to the Richards equation. Although predicted water table drawdown was somewhat slower than was observed, agreement between the numerical solutions and experimental observations was generally good. Approximate methods were also used to characterize drainage and subirrigation and were found to be in good agreement with solutions to the more exact Richards equation and with experimental results when a variable drainage porosity is considered. In view of significant field variability of soil properties and the difficulty of measuring those properties, required by the Richards equation, it appears that simpler, approximate methods will continue to be more useful than the exact approach for predicting water table movement under drainage and subirrigation conditions.

77:04A-026
OBSERVATIONS OF SOIL WATER AND SALT MOVEMENT UNDER DRIP AND FLOOD IRRIGATION IN AN APPLE ORCHARD,
Obbink, J.G., and Alexander, D.M.
Commonwealth Scientific and Industrial Research Organization, Division of Horticultural Research, Merbein, Victoria 3505, Australia.
Agricultural Water Management, Vol. 1, No. 2, p 179-190, September 1977. 4 fig, 3 tab, 10 ref.

Descriptors: Soil water, Soil water movement, Soil moisture, Salts, Salinity, Saline soils, Flood irrigation, Surface irrigation, Irrigation practices, Irrigation systems, Orchards, Apples, Crop response.

Part of a mature apple orchard, previously flood irrigated, was converted to drip irrigation in August 1971 and maintained until May 1975. The remainder of the orchard was irrigated as before. Annual estimates were made of moisture, total soluble salts and chloride content of soil samples and of growth, leaf chloride and yield of trees from the two irrigation treatments. Soil moisture was also monitored with a neutron moisture meter. Very high salt concentrations were observed in the various soil layers in the drip irrigation treatment. The flood irrigation treatment had lower and less variable concentrations of salts. Yields and chloride content of leaves sampled each January did not differ significantly between treatments. Tree girths were smaller under drip irrigation. The drip system, using a low pressure head, filtered water and outlets wrapped in fiberglass, operated satisfactorily for the period of the trail.

77:04A-027
UNIFORM IRRIGATION WITH A LOW-HEAD BUBBLER SYSTEM,
Rawlins, S.L.
United States Department of Agriculture, Agricultural Research Service, United States Salinity Laboratory, 4500 Glenwood Drive, Riverside, California 92501.
Agricultural Water Management, Vol. 1, No. 2, p 167-178, September 1977. 8 fig, 1 tab, 3 ref.

Descriptors: Irrigation, Irrigation systems, Irrigation efficiency, Irrigation practices, Gravitational water, Irrigation engineering, Hydraulics.

Existing closed-conduit irrigation systems are capable of saving water by increasing application uniformity. But, because most of them require pumping to pressurize water for distribution, the water is saved often at the expense of increased energy consumption. This paper describes a new irrigation system that reduces the energy requirement by using inexpensive, thin-walled, corrugated plastic pipe of sufficient diameter that the pressure head often available from a surface ditch is sufficient. A simple installation technique, giving extremely high application uniformity, is described for the system for permanent crops. Costs for the system can be less than for comparable sprinkler or drip irrigation systems.

77:04A-028
LATERAL FLUSHING VALVES: A GUIDE TO PLANNING, INSTALLATION, OPERATION AND MAINTENANCE,
Beth, F.
AMIAD Filtration and Irrigation Systems, M.P. Hevel, Khorazim, Israel.
Drip/Trickle Irrigation, Vol. 2, No. 1, p 27-29, January-February, 1977.

Descriptors: Irrigation, Irrigation systems, Irrigation practices, Suspended solids, Sprinkler irrigation, Orifices, Velocity.

There is now a well recognized need for regular cleaning of irrigation lines where equipment with relatively small orifices is used; as with sprinklers, spray and mist nozzles, drippers, and simple orifices. The need becomes even more critical when the dirt load in the available water is high. The ability of a system to flush the irrigation network is provided in the lateral flushing valve, which has been developed during the last few years. It provides an automatic flushing action for cleaning all the irrigation lines at least once during each irrigation cycle.

77:04A-029
INFLUENCE OF TRICKLE AND SURFACE IRRIGATION ON RETURN FLOW QUALITY,
Wierenga, P.J.
New Mexico State University, Department of Agronomy, Las Cruces, New Mexico 88003.
Publication No. EPA-600/2-77-093, May 1977. 158 p, 29 fig, 48 tab, 12 ref, 1 append.

Descriptors: Surface irrigation, Irrigation systems, Irrigation practices, Return flow, Cotton, Salts, Salinity, Soil investigations, Irrigation efficiency, Soil water, Soil moisture.

A field study was conducted to determine the effects of controlled surface irrigation and trickle irrigation on the quality and quantity of irrigation return flow. Trickle irrigation resulted in cotton yields (3-year averages) which were 8.2 percent higher than those from the surface-irrigated plots, and with trickle irrigation 24 percent less water was used than with surface irrigation. Data on soil salt accumulation in the surface-irrigated plots showed an increase in salt concentration with depth to the clay-sand interface. Below the clay-sand interface at 80-100 cm, a sharp decrease in salt concentration was observed. It appeared that a larger change in soil salinity was produced by altering irrigation frequency than by changing irrigation efficiency. Irrigating when 50 percent of the soil water had been depleted was the irrigation frequency most conducive to salt retention by the soils. It appeared that trickle irrigation was quite effective in controlling the volume of return flow, while maintaining relatively low salinity levels in the soil around the trickle emitters. Accumulated salts were readily moved away from trickle lines by heavy preplant irrigations or intense rains.

77:04A-030
MINIMIZING SALT IN RETURN FLOW THROUGH IRRIGATION MANAGEMENT,
United States Department of Agriculture, Agricultural Research Service, United States Salinity Laboratory, Riverside, California 92502.
Publication No. EPA-600/2-77-134, July 1977. 111 p, 43 fig, 37 tab, 23 ref, 2 append.

Descriptors: Arizona, Salts, Irrigation, Irrigation effects, Return flow, Leaching, Alfalfa, Surface irrigation.

Two field experiments are being conducted in southwestern Arizona to investigate the potential of reducing the salt load in irrigation return flow by decreased leaching. Three leaching treatments of 5, 10, and 20 percent, replicated nine times for citrus and five times for alfalfa, were established and compared with conventional flood irrigation management.

77:04A-031
ECONOMIC ANALYSES OF MULTIPLE PIVOT IRRIGATION ON A DROUGHTY SOIL,
Otterby, M.A., and DeBoer, D.W.
Minnesota University, Department of Agricultural Engineering, Minnesota.
Presented at the 1977 Annual Meeting of the American Society of Agricultural Engineers, June 26-29, 1977, Raleigh, North Carolina, North Carolina State University, p 1-18. 4 fig, 6 tab, 8 ref.

Descriptors: Sprinkler irrigation, Crop production, Corn, Alfalfa, Economics, Soils, Irrigation practices.

Economic analyses consisting of annual costs and returns were used to compare the profitability of using one center pivot irrigation machine on more than one field. Corn and alfalfa yields from an associated field study were used as a basis for the analyses.

77:04A-032
CENTER PIVOT END SPRINKLER PATTERN ANALYSIS AND SELECTION,
Solomon, K., and Kodama, M.
Rain Bird Technical Services, Logan, Utah.
Presented at the 1977 Annual Meeting of the American Society of Agricultural Engineers, June 26-29, 1977, Raleigh, North Carolina, North Carolina State University, p 1-24. 6 fig, 2 tab, 9 ref, 4 equ.

Descriptors: Sprinkler irrigation, Irrigation efficiency, Irrigation engineering, Irrigation design, Sprinklers.

Application patterns from center pivot end sprinklers are determined from stationary distribution curves and presented in generalized form. Criteria are defined for evaluating end sprinkler selections relative to efficient utilization of land, water, and energy resources. Procedures are given for relating sprinklers and machine variables with end sprinkler performance.

77:04A-033
ECONOMICS OF CENTER PIVOT END GUNS,
von Bernuth, R.D.
Rain Bird Sprinkler Manufacturing Company, Logan, Utah.
Presented at the 1977 Annual Meeting of the American Society of Agricultural Engineers, June 26-29, 1977, Raleigh, North Carolina, North Carolina State University, p 1-9. 3 fig, 3 tab, 4 ref, 3 equ.

Descriptors: Sprinkler irrigation, Economics, Irrigation practices, Irrigation engineering, Irrigation systems.

Gun type sprinklers used as "end guns" on center pivots are a popular means of gaining additional irrigated acreage. Several economic factors which result from using "end guns" should be considered before arriving at the conclusion to use one.

77:04A-034
MANUFACTURING VARIATION OF EMITTERS IN TRICKLE IRRIGATION SYSTEMS,
Solomon, K.
Rain Bird Technical Services, Logan, Utah.
Presented at the 1977 Annual Meeting of the American Society of Agricultural Engineers, June 26-29, 1977, Raleigh, North Carolina, North Carolina State University, p 1-20. 4 fig, 4 tab, 9 ref.

Descriptors: Irrigation systems, Uniformity, Irrigation efficiency, Irrigation, Irrigation practices.

Emitter manufacturing variation is shown to significantly affect trickle system efficiencies. Values of the Coefficient of Manufacturing Variation are given for several emission devices. Emission rate distributions are shown for typical trickle system conditions, and are evaluated according to Emission Uniformity and Water Storage Efficiency concepts.

77:04A-035
TRICKLE IRRIGATION: PREVENTION OF CLOGGING,
Gilbert, R.G., Nakayama, F.S., and Bucks, D.A.
United States Department of Agriculture, Agricultural Research Service, United States Water Conservation Laboratory, 4331 East Broadway, Phoenix, Arizona 85040.
Presented at the 1977 Annual Meeting of the American Society of Agricultural Engineers, June 26-29, 1977, Raleigh, North Carolina, North Carolina State University, p 1-23. 4 fig, 3 tab, 17 ref.

Descriptors: Clogging, Irrigation, Irrigation systems, Irrigation practices, Irrigation efficiency, Filtration, Sediment load.

Clogging of several types of trickle emitters delivering Colorado River irrigation water to mature citrus trees was prevented by a combination of filtration and chemical treatments, which removed suspended load, and controlled microbial slime development and precipitation of carbonates.

77:04A-036
SELECTING THE SYSTEM FOR THE SITE,
Shearer, M.N.
Oregon State University, Department of Agricultural Engineering, Corvallis, Oregon.
Proceedings of the 1977 Annual Technical Conference, Irrigation For All Reasons, p 45-49, February 13-15, 1977.

Descriptors: Irrigation, Irrigation systems, Irrigation practices, Soils, Soil properties, Soil physical properties, Sprinkler irrigation, Infiltration, Soil texture, Climates.

The title suggests that something about the "site" has considerable influence on the type of irrigation system that should be installed at a specific location. If we assume that this is true, we are confronted with the problem of identifying those characteristics which are significant.

77:04A-037
ESTIMATING RUNOFF FROM FURROW IRRIGATION,
Ohmes, F.E., and Manges, H.L.
Garden City Branch Experiment Station, Irrigation Engineering Division, Garden City, Kansas.
Transactions of the American Society of Agricultural Engineers, Special Edition, Vol. 20SW, p 1089-1092, December 20, 1977. 3 fig, 2 tab, 6 ref, 15 equ.

Descriptors: Furrow irrigation, Inflow, Runoff, Irrigation efficiency, Equations, Flow rates.

Inflow into and outflow from furrows during irrigation were measured. Both theory and field measurements have shown that runoff rate from a graded furrow can be expressed as a function of time for the rising portion of the runoff hydrograph and then becomes constant. Volume of runoff can be determined by integrating the runoff equations.

77:04A-038
IMPROVED SEMI-AUTOMATIC GATES FOR CUT-BACK SURFACE IRRIGATION SYSTEMS,
Evans, R.G.
Colorado State University, Agricultural and Chemical Engineering Department, Fort Collins, Colorado.
Transactions of the American Society of Agricultural Engineers, Special Edition, Vol. 20SW, p 105-108, 112, February 20, 1977. 7 fig, 1 tab, 12 ref.

Descriptors: Surface irrigation, Gates, Irrigation systems, Automation, Furrow irrigation, Furrow systems, Irrigation design, Irrigation efficiency, Irrigation practices.

One of the most effective means of improving application efficiency and uniformity in furrow irrigation systems is the cut-back concept. The cut-back systems are very amendable to automation, however, one of the largest obstacles to its widespread use has been a lack of simple, inexpensive and reliable equipment to automate the systems. A much simplified version of a semi-automatic "drop-open" type of gate has been developed and its construction, field operation and reliability are discussed in this paper. A simplified "drop-closed" type of gate is also discussed. Both gate types are constructed of aluminum, use mechanical Coret timers and are interchangeable.

77:04A-039
TRICKLE AND SPRINKLER IRRIGATION OF GRAIN SORGHUM,
Ravelo, C.J., Hiler, E.A., and Howell, T.A.
Agricultural Engineering Department, Texas A & M University, College Station, Texas.
Transactions of the American Society of Agricultural Engineers, Special Edition, Vol. 20SW, p 96-99, February 20, 1977. 5 fig, 3 tab, 18 ref.

Descriptors: Sprinkler irrigation, Crop response, Grain sorghum, Lysimeters, Crop production, Irrigation systems, Water measurement, Water control, Water balance.

Crop response and water use efficiency (ratio of grain yield to total crop water use) of grain sorghum in an environmentally controlled lysimeter installation were investigated using trickle and sprinkler irrigation. Also, effects of different trickle irrigation frequencies on the crop growth and grain yield were studied. Results indicate no significant differences in yield or water use efficiency when using trickle and sprinkler irrigation with three irrigations per week. Also, trickle irrigation frequencies of 1, 2, and 3 irrigations per week appeared to have no significant effect on yield or water use efficiency of grain sorghum on a layered sandy loam soil.

77:04A-040
MANAGEMENT OF BED-FURROW IRRIGATED SOIL WITH LIMITED-AND NO-TILLAGE SYSTEMS,
Musick, J.T., Wiese, A.F., and Allen, R.R.
United States Department of Agriculture, Southwestern Great Plains Research
Center, Bushland, Texas.
Transactions of the American Society of Agriculture Engineers, Special Edition,
Vol. 20SW, p 666-672, August 20, 1977. 1 fig, 4 tab, 8 ref.

Descriptors: Irrigation systems, Furrow systems, Crop production, Management, Soil water, Irrigation water, Grain sorghum, Furrow irrigation, Cultivation.

Limited and no-tillage management in the Southern Plains can be beneficially used in irrigated cropping systems. About 75 percent of the irrigation in this region is by the graded-furrow method. Learning how to manage beds and furrows between crops is essential for development of practical management systems. This paper reports the results of 7 years of field research in developing and evaluating limited and no-tillage management systems for irrigated crop production.

77:04A-041
SOLAR TECHNOLOGY APPLICATIONS: A LITERATURE REVIEW OF SOLAR THERMAL POWERED IRRIGATION SYSTEMS,
Newkirk, H.W.
California University, Technical Information Department, Lawrence Livermore
Laboratory, Livermore, California 94550.
Publication No. UCID-17510, June 1977. 18 p, 1 fig.

Descriptors: Thermal power, Power plants, Irrigation systems, Pumping plants, Pumping.

This report is a single reference source which summarizes published information on solar thermal powered irrigation systems. It is a compilation of literature references and a survey of on-going work in this field. Much of the material here outlined is tentative, rapidly changing, and highly variable in time and place. The following information should therefore be considered a guide rather than a set of specifications and will be updated as additional information and references appear in the literature.

77:04A-042
CONTROL OF SEDIMENTS, NUTRIENTS, AND ADSORBED BIOCIDES IN SURFACE IRRIGATION RETURN FLOWS,
Carter, D.L., and Bondurant, J.A.
United States Department of Agriculture, Agricultural Research Service, Western
Region, Snake River Conservation Research Center, Kimberly, Idaho 83341.
Publication No. EPA-600/2-76-237, October 1976. 45 p, 2 fig, 7 tab, 49 ref.

Descriptors: Sediments, Sedimentation, Nutrients, Return flow, Surface irrigation, Sediment control, Erosion control, Runoff, Surface runoff, Technology, Irrigation, Soil conservation, Pesticides, Management.

The technology available for the control of sediments, nutrients, and adsorbed biocides in surface irrigation return flows has been reviewed and evaluated. Some of this technology could be applied immediately to reduce sediment and associated nutrient and biocide concentrations in surface irrigation return flows. Much of the available information needs to be integrated to develop improved control practices. New ideas and new control technology are needed. Economic incentive programs are needed to improve acceptance of control technology. The factors controlling erosion and subsequent sediment concentrations in surface irrigation return flows, and how these factors can be managed to reduce erosion and sediment concentrations are reviewed and discussed.

SECTION XVI

WATER QUANTITY MANAGEMENT AND CONTROL

GROUNDWATER MANAGEMENT (GROUP 04B)

77:04B-001
MANAGEMENT MODEL FOR GROUNDWATER DEVELOPMENT,
Willis, R., and Newman, B.A.
Cornell University, School of Civil and Environmental Engineering, Ithaca, New York.
Journal of the Water Resources Planning and Management Division, Proceedings of the American Society of Civil Engineers, Vol. 103, No. WR1, Proceedings Paper No. 12953, p 159-171, May 1977. 1 fig, 3 tab, 29 ref.

Descriptors: *Groundwater resources, *Aquifers, *Mathematical models, *Water management (applied), *Optimization, Water supply, Economic efficiency, Water demand, Long-term planning, Finite element analysis, Flow, Control, Wells, Pumping, Equations, Systems analysis, Linear programming, Algorithms, Water resources development.

A mathematical model for the optimal dynamic management of regional groundwater supply resources is presented. The model, predicated upon a Galerkin finite element formulation of flow in heterogeneous anisotropic porous media allows management decisions to be made regarding; (1) the possible well development sites within the groundwater basin; and (2) the optimal pumping rates needed to meet an exogenous water demand in each planning period. The planning model minimizes the total discounted operational costs over the planning horizon. The algorithm solves a succession of linear programming problems obtained by linearizing the concave objective function using a generalized Taylor series expansion about an initial feasible decision vector. The management problem, structured as a problem in optimal control, is solved using Tui's concave programming algorithm. Results indicate the effectiveness of the model for the planning and development of groundwater resources.

77:04B-002
SUBSURFACE DRAINAGE COST AND HYDROLOGIC MODEL,
Bhattacharya, A.K., Foroud, N., Chieng, S-T., and Broughton, R.S.
Macdonald College, Department of Agricultural Engineering, Ste. Anne de Bellevue Quebec, Canada.
Journal of the Irrigation and Drainage Division, Proceedings of the American Society of Civil Engineers, Vol. 103, No. IR3, p 299-308, September 1977. 4 fig, 4 tab, 7 ref.

Descriptors: *Drainage practices, *Tiles, *Water balance, *Economics, Hydrology, Water table, Weather data, Simulation analysis, Computers, Costs, Soil water, Effects, Frequency analysis, Mathematical models, Systems analysis.

A computer simulation water balance model was used to analyze the variation of daily water table depths in the field using 27 years of weather data and soil water parameters. The high water table in the study area resulted from a cool moist climate and poor natural drainage condition. The effects of drainage rates and drain depths on the water table were studied. A frequency analysis was made to obtain the recurrence intervals of specific water table depths for various successive numbers of days. The net financial benefit from the system was evaluated corresponding to various chances of crop failure due to inadequacy of the drainage system during its assumed amortization period. In conclusion, in the absence of definite functional relationships between the processes of a soil-water-plant system, a computer simulation approach becomes valuable in predicting water table depths and their relationships to other pertinent parameters.

77:04B-003
MANAGEMENT OF GROUNDWATER AND SURFACE WATER VIA DECOMPOSITION,
Haimes, Y.Y., and Dreizin, Y.C.
Case Western Reserve University, Department of Systems Engineering, Cleveland, Ohio.
Water Resources Research, Vol. 13, No. 1, p 69-77, February 1977. 2 fig, 1 tab, 23 ref.

Descriptors: *Groundwater, *Management, *Surface waters, *Conjunctive use, *Methodology, Streams, Networks, Reservoirs, Optimization, Control, Water supply, Regional analysis, Costs, Pumping recharge, Water requirements, Equations, Mathematical models, Systems analysis.

Developed is a methodology for solving the problems of conjunctive use of a large-scale complex groundwater system, a network of streams, and reservoirs all interacting with one another. Decomposing the model of a large-scale aquifer system as well as that of a stream network into interacting submodels provides an improved mathematical model of the entire physical system. A theorem is proved that establishes the necessary conditions for the existence of a solution to the optimal control problem associated with the management of the groundwater system. A sample problem is formulated in which the options of groundwater operations and surface water supply are conjunctively utilized to meet the water needs of several water users in a basin; the objective function is benefit maximization. The problem of optimal management is solved via decomposition and multilevel approach.

77:04B-004
MINIMIZING COSTS IN WELL FIELD DESIGN IN RELATION TO AQUIFER MODELS,
Bostock, C.A., Simpson, E.S., and Roefs, T.G.
Arizona University, Department of Hydrology and Water Resources, Tucson, Arizona.
Water Resources Research, Vol. 13, No. 2, p 420-426, April 1977. 4 fig, 8 ref.

Descriptors: *Wells, *Costs, *Optimization, *Economic efficiency, *Aquifers, Probability, Demand, Pumping, Annual, Water table, Methodology, Decision making, Seasonal, Groundwater, Mathematical models, Operations research.

For a given production rate from a proposed well field, well construction and replacement costs decrease with fewer and larger wells spaced farther apart, while pumping lift costs increase. A method for minimizing the sum of these two costs is presented which uses a two-dimensional uniform grid of wells to select a combination of well spacing and well capacity that minimizes costs for a given demand. Uncertainty in field permeability at future well sites is treated by averaging the possible outcomes over all wells in accord with a probability density function for permeability values. The method assumes an annual cycle whereby the water table declines owing to pumping in a dry season and is recharged to its initial state during a wet season. It is concluded that the method is suited by Bayesian decision theory application and that it is independent of the mathematical theory for groundwater flow used to predict aquifer response in the aquifer cell model.

77:04B-005
STATISTICAL ANALYSIS OF THE IMPACT OF GROUNDWATER PUMPAGE ON LOW-FLOW HYDROLOGY,
Fetter, C.W., Jr.
Wisconsin University, Department of Geology, Oshkosh, Wisconsin.
Water Resources Bulletin, Vol. 13, No. 2, p 309-323, April 1977. 7 fig, 1 tab, 8 ref.

Descriptors: *Pumping, *Groundwater, *Interbasin transfers, *Low flow, *Diversion, *Wisconsin, Hydrology, Water table, Withdrawal, Forecasting, Regression analysis.

Heavy groundwater pumpage in the Yahara River basin has resulted in lowering of the water table. As a means of preserving surface water quality, treated wastewater was diverted from the upper basin in 1958. The two mentioned factors have acted together to produce a depletion in Yahara River streamflow of more than 50% during periods of low flow. Regression analyses showed that the annual 7-day and 60-day low flows have a statistically significant correlation with mean annual flow.

Using predictions of future mean annual discharge of the river with increasing interbasin transfers, it was shown that by 1990 there is a significant probability that in some years the 60-day low flow in the river will be zero. The drainage area of the upper basin is 328 sq mi above McFarland, Wisconsin.

77:04B-006
SENSITIVITY ANALYSIS IN AQUIFER STUDIES,
Aguado, E., Sitar, N., and Remson, I.
Stanford University, School of Earth Sciences, California.
Water Resources Research, Vol. 13, No. 4, p 733-737, August 1977. 4 fig, 1 tab, 8 ref.

Descriptors: *Aquifers, *Management, *Planning, *Linear programming, *Groundwater, Optimization, Wells, Discharge (water), Dewatering, Pumping, Hydraulic conductivity, Equations, Constraints, Mathematical models, Systems analysis.

A method is presented for determining in which areas detailed knowledge of aquifer characteristics and conditions is most critical to the success of a management plan. These questions are answered by using sensitivity analysis to determine how variations in parameters and input data affect the optimal solution of a linear programming management model. The model uses either finite element or finite difference approximations of the groundwater equations as constraints. The optimal locations and discharge rates of wells have been determined for dewatering a rectangular area to a specified level while minimizing steady state total pumping rate and maintaining hydraulic heads in the dewatered area at or below the specified value. The area is in a small aquifer having constant head boundaries. Sensitivity analysis has shown that the optimal steady state solution is most sensitive to hydraulic conductivity at and near the aquifer boundaries parallel to the length of the dewatered area. Thus field exploration and testing should be concentrated on determination of hydraulic conductivity in those areas.

77:04B-007
OBSERVATION WELL RESPONSE TIME AND ITS EFFECT UPON AQUIFER TEST RESULTS,
Black, J.H., and Kipp, K.L., Jr.
Institute of Geological Sciences, London (England).
Journal of Hydrology, Vol. 34, No. 3/4, p 297-306, August 1977. 3 fig, 2 tab, 5 ref.

Descriptors: *Observation wells, *Time lag, *Aquifer testing, *Pumping, Aquifer characteristics, Equations, Mathematical studies, Curves, Graphical analysis, Theis equation, Water levels, Water wells, Transmissivity, Storage coefficient, Drawdown, Hydraulic conductivity.

The concept of observation-well response time was introduced in the context of aquifer pump tests. Previous work on hydrostatic time lag and slug tests was considered together with the precise way in which an observation well responds during an aquifer test. Using the concepts of Hvorslev, an equation was produced linking observation-well response time, alpha, and a dimensionless response-time factor beta. The Theis equation was modified by various values of beta to derive a set of type curves. The 2 parameters alpha and beta were related by a simple equation involving aquifer transmissivity, T, and storativity, S. Both alpha and beta can be obtained independently from a slug test, while alpha alone can be obtained independently from a slug test. An example was given showing the effect of beta upon aquifer test results, and the value of alpha calculated from the aquifer test analysis was corroborated by slug test results. The definition of beta was used to show in what circumstances it will be important and how its effect can be reduced to a minimum. The introduction of slug testing of observation wells as standard practice for all aquifer tests was suggested.

77:04B-008
AN ARCHETYPAL LINEAR PROGRAMMING MODEL FOR OPTIMAL INTERTEMPORAL ALLOCATION OF GROUNDWATER TO AGRICULTURAL ACTIVITIES,
Weisz, R.N., and Towle, C.[illegible]., Jr.
Arizona University, Department of Agricultural Economics, Tucson, Arizona.
Water Resources Bulletin, Vol. 13, No. 5, p 1035-1046, October 1977. 3 fig, 2 tab, 20 ref.

Descriptors: *Groundwater, *Water allocation (policy), *Linear programming, *Economic efficiency, *Planning, Simulation analysis, Constraints, Aquifers, Discount rates, Equations, Mathematical models, Systems analysis, Optimization, Water utilization, Water supply.

In the past, researchers have applied a variety of analytical techniques for maximizing the present value of a stock resource: simulation, calculus of variations, stochastic dynamic programming, and optimal control theory. Presented herein is a more operational approach--linear programming. A simplified, broadly drawn example from Southwest agriculture is used for demonstrating the model structure and output; the method is based on a set of state transformation operations that prevent the additivity assumption of linear programming from being violated. The test case concerns a geologically isolated aquifer wholely managed by one entity (for example, the farmer) who must maximize benefits over a two-year planning period. A comparison is made of the simulation run with that of optimization. The archetypal linear programming model for maximizing the present value of net benefits from a groundwater stock resource is proven over a range of realistic parameter values. It should find innumerable applications in the economic analysis of Southwest agricultural problems in areas where basin-wide management of a groundwater resource is appropriate.

77:04B-009
MANURE MANAGEMENT IN AN IRRIGATION BASIN RELATIVE TO SALT LEACHATE TO GROUNDWATER,
Pratt, P.F., Davis, S., and Laag, A.E.
California University, Department of Soil Science, Riverside, California 92521.
Journal of Environmental Quality, Vol. 6, No. 4, p 397-402, October-December 1977.
7 fig, 2 tab, 10 ref.

Descriptors: Leaching, Cations, Root zone, Manure, Irrigation, Irrigation practices, Calcium, Magnesium, Potassium, Sodium, Salinity.

The leaching of cations from the soil root zone as a function of rate of manure and irrigation treatments, which controlled the leaching fraction and the volume of leachate, was measured during a 4-year field experiment. Large amounts of Ca, Mg, and K were accumulated in the soil, but there was a net loss of Na. Practically no K moved beyond the 1.5 m depth, which was considered the bottom of the root zone. The percent leaching of the cations added in water and in manures decreased as the rate of manure increased.

77:04B-010
INTEGRODIFFERENTIAL EQUATIONS FOR SYSTEMS OF LEAKY AQUIFERS AND APPLICATIONS 3. A NUMERICAL METHOD OF UNLIMITED APPLICABILITY,
Herrera, I., and Yates, R.
Universidad Nacional Autonoma de Mexico, Instituto de Investigaciones en Matematicas Aplicadas y en Sistemas, Mexico 20, Distrito Federal, Mexico.
Water Resources Research, Vol. 13, No. 4, p 725-732, August 1977. 6 fig, 15 ref, 41 equ.

Descriptors: Aquifers, Aquifer management, Aquifer systems, Aquifer testing, Mathematics, Mathematical studies, Groundwater.

The integrodifferential equation formulation of leaky aquifer mechanics is used to develop a numerical method of unlimited applicability based on the finite element technique. This approach reduces the dimensionality of the problem and effectively uncouples the equations corresponding to each of the aquifers. Thus the number of nodes required and the bandwidth of the matrices involved are significantly reduced. Consequently, storage and computer time are decreased by a factor greater than 30 in axially symmetric problems and by a considerably greater factor in the absence of such symmetry.

77:04B-011
INJECTION/EXTRACTION WELL SYSTEM--A UNIQUE SEAWATER BARRIER,
Sheahan, N.T.
Brown and Caldwell, Pasadena, California.
Ground Water, Vol. 15, No. 1, p 32-50, January-February, 1977. 12 fig, 10 ref.

Descriptors: *Saline water intrusion, *Injection wells, *Groundwater barriers, *California, Wells, Water wells, Groundwater recharge, Aquifers, Sea water, Salinity, Irrigation, Waste water disposal, Artificial recharge, Groundwater, Hydrology.

A multiple-aquifer system in the bayfront area of Palo Alto, California, is being intruded with seawater from San Francisco Bay. In order to combat this potential degradation of the groundwater supplies in the area, a sea water intursion barrier is being constructed, consisting of a series of injection wells used to inject 2.0 million gallons per day (7.6 million liters per day) of reclaimed wastewater into a shallow aquifer. The injected water is subsequently removed by a similar system of extraction wells to avoid any possible degradation of the water supply aquifers from this source and to allow reuse of the reclaimed wastewater. The investigation phase included test drilling, aquifer testing, and injection testing to determine the feasibility of the injection/extraction (I/E) concept. The number, spacing, and location of I/E doublets were optimized by using a digital computer model. The double-cased, double-screened wells were constructed, using corrosion-resistant materials, and the wells were designed for ease of routine maintenance. In operation, injection and extraction will be computer controlled by sensing piezometric levels in a series of monitor wells. Water pumped from the extraction wells will be sold for industrial and agricultural purposes. The I/E well system has been approved for Federal and State grand funding.

77:04B-012
A HIERARCHY OF RESPONSE FUNCTIONS FOR GROUNDWATER MANAGEMENT,
Dreizin, Y.C., and Haimes, Y.Y.
Mekoroth Water Company, Systems Engineering Department, Tel-Aviv (Israel).
Water Resources Research, Vol. 13, No. 1, p 78-86, February 1977. 5 fig, 4 tab, 20 ref.

Descriptors: *Groundwater, *Management, *River basins, *Aquifers, *Linear programming, Pumping, Recharge, Streams, Stress, Ohio, Input-output analysis, Simulation analysis, Methodology, Behavior, Hydraulics, Mathematical models, Equations, Systems analysis.

The physical system dealt with in this paper is a river basin with multiunit aquifers and interconnected streams. The problem is how to model this complex system and then to represent it in terms of its response to stress in the form of pumpage and recharge. The system responds to pumpage in two ways: as drawdown or as flow between streams and aquifers. A hierarchy of linear mathematical models for a large-scale physical system response to stress has been developed. For the system response, an explicit mathematical expression is used to couple the physical system with the formulation of a management model. The models developed herein have been successfully tested on a case study of the Fairfield-New Baltimore area at the lower part of the Great Miami River in southwestern Ohio.

77:04B-013
FIELD-MEASURED WATER UPTAKE OF SUDANGRASS ROOTS AS AFFECTED BY FERTILIZATION,
Fluhler, H., Ardakani, M.S., Szuszkiewicz, T.E., and Stolzy, L.H.
California University, Riverside, California.
Agronomy Journal, Vol. 69, No. 2, p 269-274, March-April, 1977. 8 fig, 23 ref, 11 equ.

Descriptors: Fertilizers, Fertilization, Groundwater, Nitrates, Leaching, Roots, Evapotranspiration, Groundwater resources, Water quality control.

Cultural practices could affect the flow of water and solutes toward groundwater. In this field experiment we analyzed the effect of fertilization on water uptake of sudangrass and its indirect influence on deep drainage and nitrate leaching. Root water uptake was calculated as sink term in the continuity equation using successive measurements of water content and matric potential profiles in connection with field measured hydraulic conductivity functions. The experiment was conducted in three field plots on Hanford fine sandy loam. Fertilization increased dry matter production and water uptake significantly and reduced deep drainage and nitrate leaching. Water uptake patterns and root length distribution was not correlated. Mainly due to fertilization with nitrate nitrogen, the evapotranspiration approximated the amount of irrigation water applied. These results indicate that optimum water and fertilizer use and minimum groundwater pollution per unit crop production are intimately linked together.

77:04B-014
PREDICTING PHOSPHATE MOVEMENT THROUGH SOIL COLUMNS,
Sawhney, B.L.
Connecticut Agricultural Experiment Station, New Haven, Connecticut.
Journal of Environmental Quality, Vol. 6, No. 1, p 86-89, January-March, 1977.
5 fig, 21 ref.

Descriptors: Groundwater, Phosphorus, Soils, Soil investigations, Soil properties, Waste water, Sorption.

To assess the potential pollution of groundwater with P from septic tank drainfields, sorption capacities of various soils were determined over an extended period of time and related to P movement through soil columns using solutions having P concentrations similar to waste waters. The amounts of P sorbed by fine sandy loam (fsl) and silt loam (sil) soil columns before breakthrough occurred were approximately equal to the sorption capacities determined from isotherms obtained over a sufficiently long reaction time of about 200 hours. In Merrimac fsl, breakthrough occurred after about 50 pore volumes of waste water had passed through the column while about 100 pore volumes passed through Buxton sil before the breakthrough occurred. Following breakthrough, concentration of P in the effluent continued to increase and approached the influent concentration after several hundred pore volumes of effluent had passed through the columns. The results, thus, suggest that while most deep soils should effectively remove P from waste water, groundwater under drainfields installed in soils of low P sorption capacity after prolonged use may contain undesirably large concentrations of P.

77:04B-015
POSSIBLE ENERGY SAVINGS IN IRRIGATION,
Gilley, J.R., and Watts, D.G.
Nebraska University, Department of Agricultural Engineering, Lincoln, Nebraska.
American Society of Civil Engineers Journal of the Irrigation and Drainage Division, Vol. 103, No. IR4, p 445-457, December 1977. 3 fig, 6 tab, 20 ref, 2 append.

Descriptors: *Irrigation practices, *Irrigation efficiency, *Pumping, Energy, Sprinkler irrigation, Water reuse, Center pivot systems, Water pressure, Farm equipment, Fertilizers, Nitrogen compounds, Nebraska.

Studies in Nebraska have shown that over 40% of all the energy consumed by production agriculture is used for pumping water from wells, which supply about 80% of the irrigation water requirements. Reduction of energy used in irrigation pumping would thus have significant impact. Six procedures, utilized singly or in various combinations, show strong energy-saving potential: (1) increased irrigation efficiency--better design and management of center pivot and surface systems; greater use of trickle, subsurface, runoff reuse systems as rising fuel prices make them cost effective; (2) improved pumping plant efficiency; (3) reduced water pumping--advances in irrigation scheduling; (4) lowering pressure of sprinkler systems; (5) scheduling to decrease electric peak demand, and; (6) minimizing nitrogen fertilizer losses due to deep percolation--fertilizer is conserved through irrigation scheduling, thus conserving the energy used in its manufacture. Energy savings of 40%-50% are considered attainable through these procedures.

SECTION XVII

WATER QUANTITY MANAGEMENT AND CONTROL

WATERSHED PROTECTION (GROUP O4D)

77:04D-001
GULLY WALL STABILITY IN LOESS-DERIVED ALLUVIUM,
Bradford, J.M., and Piest, R.F.
Agricultural Research Service, Columbia, Missouri.
Soil Science Society of America Journal, Vol. 41, No. 1, p 115-122, January-February, 1977. 7 fig, 3 tab, 13 ref.

Descriptors: *Soil strength, *Gully erosion, Soil mechanics, Loess, Erosion, Tensiometers, Piezometers, Slope stability, Groundwater, Sedimentation, On-site investigations, Water pollution.

A field study was made on an instrumented vertical slope to investigate the triggering mechanisms that initiate gully wall failure in loess-derived alluvium. The relevance of hydrology, soil morphology, and soil mechanisms to an understanding of gully slumping was examined. Conventional limit equilibrium slope stability methods were of little value in predicting failure volumes or in understanding the failure mechanics. The geometry and time of failure were greatly influenced by the structural features of loess-derived alluvium and by the dependence of the shear strength on the pore water pressure within the soil.

77:04D-002
AREAWIDE WATER QUALITY MANAGEMENT IN AN ENERGY DEVELOPMENT AREA,
Judy, C.H., and Gartner, A.
Yellowstone-Tongue A.P.O., Post Office Box 503, Broadus, Montana 59317,
Water Resources Bulletin, Vol. 13, No. 4, p 835-841, August 1977. 1 fig, 2 tab, 5 ref.

Descriptors: Water quality, Water quality management, Energy, Watersheds, Watershed management.

A Section 208, Areawide Waste Treatment Management Project, is attempting to develop an implementable water quality management plan for an energy impacted area. Staff members and consultants are investigating point and nonpoint sources. On a short-term basis, population growth and construction will have a greater impact on water quality than strip mining.

77:04D-003
DRAIN DISCHARGE FROM A LEVEL AGRICULTURAL WATERSHED,
Sharma, T.C., and Irwin, R.W.
Guelph University, School of Engineering, Ontario, Canada.
Journal of the Irrigation and Drainage Division, American Society of Civil Engineers, Vol. 103, No. IR4, Proceedings Paper 13399, p 429-443, December 1977. 7 fig, 3 tab, 12 ref.

Descriptors: *Drainage, *Agricultural watersheds, *Discharge (water), Drainage patterns (geologic), Hydraulic conductivity, Hydrography, Hydrology, Model studies, Surface runoff, Tile drainage, Watersheds (basins), Subsurface drainage.

A hypothesis was developed that watershed discharge from rainfall, for nonfreezing periods from a tile drained level watershed, was mainly tile flow with negligible amounts of surface runoff and base flow. Daily discharges at the watershed outlet were due to depletion of 2 parallel linear reservoirs. A fast reacting reservoir, represented by the physical shallow plowed layer, constituted nearly 40% of the total runoff volume. The slow reacting reservoir, represented by the subsoil zone, contributed nearly 60% of the total runoff volume.

77:04D-004
SEDIMENT DEPOSITION PATTERNS IN SIMULATED GRASS FILTERS,
Tollner, E.W., Barfield, B.J., Vachirakornwatana, C., and Haan, C.T.
Kentucky University, Department of Agricultural Engineering, Lexington, Kentucky.
Transactions of the American Society of Agricultural Engineers, Vol. 20, No. 5, p 940-944, September-October, 1977. 9 fig, 1 tab, 10 ref.

Descriptors: *Deposition (sediments), *Grasses, *Grassed waterways, *Model studies, Mathematical models, Hydraulic models, Laboratory tests, Filters, Sediments, Sediment transport, Sediment load, Sedimentation.

The principle of mass continuity was used to develop equations to predict the rate of advance of a sediment deposition front in a grass filter under steady-state flow conditions. Based on the theoretical analysis, it was shown that the rate of advance is proportional to the square root of elapsed time until the depth of deposition reaches the grass height and then linearly proportional to elapsed time. The validity of the equations was evaluated in cylindrical and flat bladed artificial media using homogeneous sediment. The agreement between predicted and observed values was excellent.

77:04D-005
SEDIMENT FROM DRAINAGE SYSTEMS FOR CLAY SOILS,
Schwab, G.O., Nolte, B.H., and Brehm, R.D.
Ohio State University, Department of Agricultural Engineering, Columbus, Ohio.
Transactions of the American Society of Agricultural Engineers, Vol. 20, No. 5, p 866-872, September-October, 1977. 3 fig, 2 tab, 10 ref.

Descriptors: *Sediment yield, *Drainage systems, *Ohio, *Clays, Tile drainage, Surface drainage, Soils, Measurements, Testing procedures, On-site tests, On-site investigations, Runoff, Agriculture, Irrigation, Rainfall, Crops, Corn (field), Oats, Alfalfa, Land management.

Sediment losses from tile and surface drainage systems in a lakebed soil in northern Ohio were measured for 6 years (1969-1974). Average annual losses were 2359 kg/ha from tile only and 3687 kg/ha for surface only. Calculated losses for the combination tile and surface drainage system were 2672 kg/ha. Annual measured losses ranged from about 100 to 9000 kg/ha. Average net losses from sprinkler irrigation were negligible, and usually more sediment was added than removed in the drainage water. Sediment concentration in tile flow from irrigation increased significantly with the antecedent soil moisture content. Concentrations were high at the beginning of flow but decreased to a nearly constant level after 20 hr. A possible explanation for the high concentrations is that the sediment moved in suspension with the water and not necessarily through the soil cracks. Estimates using a rainfall factor in the universal soil loss equation for surface drainage were 89% of the measured losses with an r sq value of 0.25, significant at the 99% level. Estimates using a runoff factor were 74% of the measured losses with an r sq value of 0.35, also significant at the 99% level.

77:04D-006
SEDIMENT YIELD PREDICTION BASED ON WATERSHED HYDROLOGY,
Williams, J.R., and Berndt, H.D.
Agricultural Research Service, Temple, Texas.
American Society of Agricultural Engineers, 1976 Winter Meeting, Chicago, Illinois, December 14-17, 1976. Paper No. 76-2535. 14 p, 3 tab, 12 ref.

Descriptors: *Sediment yield, *Forecasting, *Hydrology, Watersheds (basins), Reservoir design, Model studies, Runoff, Computers, Erosion, Equations, Farm management, Erosion control, Costs, Curves, Soil moisture, Peak discharge.

A model for predicting sediment yield from ungaged watersheds was developed by attaching a sediment yield model to hydrologic models. The sediment-runoff model is useful in reservoir design and water quality modeling because daily, monthly, and annual sediment yield can be predicted with simple inputs and low computer costs.

77:04D-007
PREDICTION OF VELOCITY DISTRIBUTION IN A VORTEX TUBE SEDIMENT TRAP WITH TURBULENCE MODELS,
Edling, R.J., Barfield, B.J., and Haan, C.T.
Nebraska University, Panhandle Station at Scottsbluff, Nebraska.
Transactions of the American Society of Agricultural Engineers, Vol. 20, No. 2,
p 301-308, March-April, 1977. 5 fig, 2 tab, 16 ref.

Descriptors: *Sediment control, *Sediments, *Vortices, *Model studies, Mathematical models, Velocity, Flow, Sediment transport, Fluid mechanics, Hydraulics, Open channels, Distribution patterns, Rotational flow, Turbulence.

Meaningful investigation into the potential and limitations of the vortex tube sediment trap could be accomplished theoretically if prediction of velocity profiles were possible. Empirical and semi-empirical velocity prediction techniques were tested. In the empirical technique, constants combining values for mean flow velocity, wall velocity, and vortex perimeter velocity were applied; whereas in the semi-empirical technique, a two equation turbulence kinetic energy and dissipation was applied. Prediction models were tested experimentally. Results revealed a range in constants for the empirical technique which indicated that the method could only be used as a guide. The semi-empirical prediction values approximated measured velocity values.

SECTION XVIII

WATER QUALITY MANAGEMENT AND PROTECTION

IDENTIFICATION OF POLLUTANTS (GROUP 05A)

77:05A-001
A NOTE OF PLEXIGLAS HS FLUMES,
Robinson, W.H., Jr., and Wright, M.E.
Virginia Polytechnic Institute and State University, Department of Agricultural Engineering.
Water Resources Research, Vol. 13, No. 1, p 211-212, February 1977. 4 fig, 1 ref.

Descriptors: *Water measurement, *Instrumentation, *Open channels, Flumes, Hydraulics, Discharge (water), Effluents, Calibrations, Specifications, Low flow, Industrial plants, Pollutant identification.

H flumes are convenient devices for accurate measurement of open channel flows, especially if trash is present. Several of the HS (smaller) types were constructed of plexiglas and used successfully in a commerical plant to measure effluents from vegetable washers. Lumped data from the calibration of three flumes were fitted to a curve of the form y=a(x to the b power). The correlation coefficient R squared for observed versus calculated values was 0.998. A 99% confidence band fitted to the prediction curve was very narrow, indicating the high degree of accuracy of the device.

77:05A-002
CHEMICAL REDUCTION OF NITRATE BY FERROUS IRON,
Buresh, R.J., and Moraghan, J.T.
North Dakota State University, Department of Soils, Fargo, North Dakota.
Journal of Environmental Quality, Vol. 5, No. 3, p 320-325, July-September, 1976.
5 fig, 4 tab, 30 ref.

Descriptors: *Nitrates, *Denitrification, *Nitrogen, Chemical reactions, Chemicals, Iron, Air pollution, Pollutant identification.

Knowledge concerning the chemical reduction of NO3(-) to gaseous products, a process of potential practical significance as an antipollution device, is sparse. The influence of pH on chemical reduction of NO3(-)-N (approximate concentration 23 ppm) by Fe(2+) in the presence and absence of Cu(2+) was studied over a pH range from 6 to 10. After 24 hours of controlled pH incubations under a helium atmosphere NO3(-), N20, NO, N2, and NH4(+) were determined. The initial Fe(2+)/NO3(-) mole ratio was 8. Reduction of NO3(-) was negligible in the absence of Cu (2+), but was pronounced above pH 7 in the presence of approximately 5 ppm Cu(2+). Formation of HN4(+) increased with pH and was the dominant process at pH 9 and 10. Nitrous oxide and N2 accumulations were greatest in the pH range from 8 to 8.5 and negligible at pH6 and 10. Nitrite formation was small except at pH9 and 10. Trace quantities of NO accumulated during incubation if the pH was allowed to drop below 6. Levels of Cu(2+) and Fe(2+) influenced the extent and nature of NO3(-) reduction at pH8. Maximum reduction of NO3(-) (93%) and maximum gas production, equivalent to 61% of the original NO3(-), occurred when the Fe(2+)/NO3(-) mole ratio was 12 and the Cu(2+) level was approximately 10 ppm. The N20/N2 mole ratio in the evolved gases decreased as the Cu(2+) level was increased from approximately 1 to 10 ppm and as the Fe(2+)/NO3(-) mole ratio was increased from 8 to 12. Nitrate was relatively stable at a Cu(2+) content of 0.1 ppm irrespective of the Fe(2+)/NO3(-) ratio.

77:05A-003
USE OF LABORATORY EXTRACTION DATA TO PREDICT LOSSES OF DISSOLVED INORGANIC PHOSPHATE IN SURFACE RUNOFF AND TILE DRAINAGE,
Sharpley, A.N., Tillman, R.W., and Syers, J.K.
Massey University, Department of Soil Science, Palmerston North (New Zealand).

Journal of Environmental Quality, Vol. 6, No. 1, p 33-36, 1977. 4 fig, 2 tab,
14 ref.

Descriptors: *Phosphorus, *Subsurface runoff, *Measurement, *Laboratory tests, *Pollutant identification, *Phosphates, *Dissolved solids, Surface runoff, Analytical techniques, Pastures, Tile drainage, Fertilization, Foreign research.

A laboratory procedure is described which measures extractable soil inorganic phosphorus to predict losses of dissolved inorganic phosphorus (DIP) in surface runoff and subsurface tile drainage from a soil under permanent pasture in both fertilized and unfertilized conditions. The mean DIP concentration in each of several surface runoff periods was closely correlated with the amounts of inorganic phosphorus extracted by 0.1M sodium chloride from the top 5 cm of soil prior to the period. For three of the four combinations of treatments evaluated (undrained, unfertilized; drained, unfertilized, and drained, fertilized) the linear relationships obtained were similar despite large variations in the phosphorus concentrations observed. Mean DIP concentrations in surface runoff from the drained plots were consistently lower than those from the undrained plots. The relationship between the mean DIP concentrations of surface runoff and the amounts of extractable inorganic phosphorus for the undrained, fertilized plot was also linear but a greatly different gradient was obtained. Soil extraction data appear to be useful in predicting mean DIP concentrations in surface runoff from reasonably homogeneous soils under pasture. Total DIP loading correlated best with the amounts of inorganic phosphorus extracted from soil at 40-50 cm, a depth which corresponds to that of mole channels.

77:05A-004
IRRIGATION RETURN FLOW PROBLEMS IN YAKIMA VALLEY,
Spencer, J., and Horton, M.
State of Washington, Department of Ecology, Olympia, Washington.
Proceedings of National Conference on Irrigation Return Flow Quality Management, Colorado State University, Fort Collins, Colorado, p 299-306, May 16-19, 1977.
2 fig, 5 ref.

Descriptors: Return flow, Agriculture, Sediments, Phosphates, Nitrates, Water management (applied), Water quality, Irrigation, Soils, Washington.

Studies completed in recent years show that irrigated agriculture is a significant source of the pollutants in the lower reaches of the Yakima River. Sediments, phosphates and nitrates are the principal pollutants resulting from irrigation activities. Improved on-farm water mangagement practices should be undertaken to alleviate this water quality degradation. Since the passage of P.L. 92-500, attempts to apply NPDES permits to irrigation return flows have been stymied by legal questions and a lack of knowledge of relationships between farming practices, soils, weather conditions, and water quality. In addition, there are legal questions regarding the authority of irrigation districts in the State of Washington to control on-farm water management practices.

77:05A-005
THE HYDRO-SALINITY SYSTEM IN THE GRAND VALLEY,
Walker, W.R., Skogerboe, G.V., Evans, R.G., and Smith, S.W.
Colorado State University, Department of Agricultural and Chemical Engineering, Fort Collins, Colorado 80523.
Proceedings of National Conference on Irrigation Return Flow Quality Management, Colorado State University, Fort Collins, Colorado, p 361-367, May 16-19, 1977.
7 fig, 3 tab, 13 ref.

Descriptors: Colorado, Colorado River, Salinity, Salts, Groundwater, Return flow, Seepage, Deep percolation.

The Grand Valley hydro-salinity system is described by research data collected over an eight-year period. A review of previous estimates indicates the great variability that can be expected when data are few and of poor quality. The Grand Valley system contributes approximately 630,000 metric tons of salts to the river annually. This figure represents 78 metric tons of salt per hectare-meter of water reaching the underlying groundwater aquifer from irrigation return flows with canal and ditch seepage contributing 23 percent of the salt pickup, lateral seepage 32 percent, and on-farm head ditch seepage and deep percolation losses contributing the remaining 45 percent of the salt pickup.

77:05A-006
TOXIC METALS IN GROUNDWATER OF THE FRONT RANGE, COLORADO,
Klusman, R.W., and Edwards, K.W.
Colorado School of Mines, Department of Chemistry, Golden, Colorado.
Ground Water, Vol. 15, No. 2, p 160-169, March-April, 1977. 6 fig, 7 tab, 14 ref.

Descriptors: *Heavy metals, *Groundwater, *Colorado, Trace elements, Water quality, Cadmium, Copper, Iron, Lead, Manganese, Mercury, Zinc, Hydrogen ion concentration, Oxidation-reduction potential, Specific conductivity, Distribution, Mineralogy, Plumbing, Water pollution, Geochemistry.

A study of toxic trace metal distribution in groundwaters of the Front Range mineral belt, Colorado, and adjacent areas was performed in order to determine the relationship of water quality to mineralization and to determine the magnitude of potential health effects. A total of 149 samples was collected and analyzed for arsenic, cadmium, copper, iron, lead, manganese, mercury, silver, and zinc. Field determinations of pH, Eh, and specific conductance were also made. The trace element data exhibited a lognormal distribution and were described utilizing the geometric mean and geometric deviation. Four populations were recognized in the samples: (1) samples in the mineral belt with plumbing contamination; (2) samples in the mineral belt without plumbing contamination; (3) samples outside the mineral belt with plumbing contamination; and (4) samples outside the mineral belt without plumbing contamination. Differences in these populations for several elements were observed utilizing the t test. Groundwaters in the mineral belt are estimated to exceed the U.S. Public Health Service limit in 14% of the samples for Cd, 1% for Cu, 51% for Fe, 74% for Mn, 2% for Hg, and 9% for Zn. Groundwaters outside the mineral belt have similar probability of exceeding the limit for Hg and lesser probabilities for all other elements.

77:05A-007
GROUNDWATER CHEMICAL QUALITY MANAGEMENT BY ARTIFICIAL RECHARGE,
Nightingale, H.I., and Bianchi, W.C.
Agricultural Research Service, Fresno, California.
Ground Water, Vol. 15, No. 1, p 15-21, January-February, 1977. 6 fig, 5 tab, 17 ref.

Descriptors: *Groundwater recharge, *Artificial recharge, *Water quality, *California, Monitoring, Recharge ponds, Pit recharge, Groundwater, Groundwater movement, Chemicals, Nitrates, Salinity, Salts, Conductivity, Specific conductivity, Wells, Water wells, Sampling.

The effectiveness of basin groundwater recharge at the Leaky Acres Recharge Facility in Fresno, California, for improving the regional groundwater quality was studied as 65,815,000 cu m of high quality surface water was recharged from 1971 through 1975. Observation wells at the facility showed some variability in chemical parameters associated with each recharge period. The long-term decreased in salinity could be described by a power law decay curve fitted by regression analysis. Without a special network of observations wells outside the facility, scientific evaluation of the enclave of recharged water is not possible. A practical evaluation of water quality changes is possible from producing water wells around the facility. However, the pumping well discharge time variations, well depth, aquifer sequence, and prior use of surrounding land must be considered, since all of these factors affect the pumped-water quality and its seasonal variability. Recharge at Leaky Acres had noticeably decreased the groundwater salinity for a distance of up to 1.6 km in the direction of the regional groundwater movement.

77:05A-008
NO SIMPLE ANSWERS ON SALINITY,
McNeill, E.

Irrigation Journal, Vol. 26, No. 6, p 16-18, November-December, 1977. 5 fig.

Descriptors: Salinity, Saline water, Saline soils, Water quality, Water quality control, Salts.

Salinity control is the most critical problem facing agricultural irrigation managers in the arid Western states, according to opinions of water specialists before a late September conference on Salt and Salinity Management at the Miramer Hotel in Santa Barbara, California. To search for solutions on how to manage agricultural lands served by irrigation waters containing an increasing build-up of salts, some 150 professionals in the management, government and educational fields met at the two-day conference to hear and study the findings of an extensive group of authoritative speakers who have actively worked on the problem.

77:05A-009
EVALUATION OF A NITRATE-SPECIFIC ION ELECTRODE,
Yu, K.Y., and Berthouex, P.M.
California University, Environmental Engineering Program, Los Angeles, California.
Journal Water Pollution Control Federation, Vol. 49, No. 8, p 1869-1901, August 1977. 1 fig, 9 tab, 7 ref.

Descriptors: *Pollutant identification, *Electrodes, *Analytical techniques, *Permselective membranes, *Nitrates, *Electrochemistry, Water chemistry, Aqueous solutions, Chemical properties, Chemical potential, Electrical equipment, Model studies, Chemical Analysis, Waste water treatment, Brucine method.

The Simple Electrode and the Standard-Addition Electrode methods are used to evaluate nitrate determinations with a nitrate-specific ion electrode and the Brucine method using effluent samples from biological treatment units. The nitrate electrode measures nitrate activity in terms of potential across a layer of water-immiscible ion exchanger held in place by an inert porous membrane. Electrode behavior follows a Nernst relation within the working range. Ionic interference is usually counteracted by the addition of a buffer to maintain constant ionic strength. The Standard-Addition or Known-Increment method involves the addition of a known amount of nitrate to a solution containing an unknown amount. The quantity of nitrate present in the initial solution is determined by measuring the change in potential produced by the additional nitrate. Grab samples of waste water effluent with nitrate concentrations ranging from 2-20 mg/liter were collected from nitrification pilot plants. Higher readings obtained with the Simple Electrode method than with Standard-Addition were attributed to greater influence of high hardness and alkalinity in the waste water on simple electrode determinations. Standard errors for nitrate determinations with the Brucine method were higher than for either electrode method, and procedures were more time-consuming, requiring reagent preparation. The specific-nitrate ion electrode is recommended as a relatively inexpensive, fast, portable means of nitrate determination in waste water for concentrations as low as 1 mg/liter nitrate-N.

77:05A-010
A MICRO-KJELDAHL TECHNIQUE FOR NITROGEN DETERMINATION IN WATER, WASTEWATER, AND SLUDGE,
Stephenson, R.L.
Butler, Fairman and Seufert, Incorporated, Carmel, Indiana.
Journal Water Pollution Control Federation, Vol. 49, No. 12, p 2499-2502, December 1977. 2 tab, 5 ref, 1 append.

Descriptors: *Nitrogen, *Ammonia, *Amino acids, *Acids, *Ammonium compounds, Testing procedures, Analytical techniques, Measurements, Nitrogen compounds, Nitrification, Application methods, Methods, Waste water treatment.

A modification of the micro-Kjeldahl technique was developed as a simplified method of measuring the nitrogen content in waste water, sludge, and water. A 5-ml sample containing ammonia nitrogen is subjected to a temperature of 340C, producing ammonium bisulfate and ammonium sulfate. The sample is diluted after digestion with ammonia-free water and its pH is raised to 10 with the addition of sodium hydroxide. The nesslerization technique is used to calculate the ammonia nitrogen concentration in the sample. The simplified technique was tested in laboratory experiments with four representative amino acids: glycine, methionine, tryptophan, and diphenylcarbazone. The nitrogen concentration of the samples were 500, 250, 50, and 10 mg/liter. Nitrogen recovery from glycine, used to represent a monoamino monocarboxy acid, ranged 92-100%. Nitrogen recovery with methionine, used as a long-change, sulfur-containing amino acid, ranged 96-124%. Tryptophan, as a heterocyclic acid, exhibited recoveries of 100-160%. Diphenylcarbazone, insoluble in acid solutions, showed poor recovery of nitrogen, ranging 8.4-120%.

SECTION XIX

WATER QUALITY MANAGEMENT AND PROTECTION

SOURCES AND FATE OF POLLUTION (GROUP 05B)

77:05B-001
EXPERIMENTAL AND SIMULATED TRANSPORT OF PHOSPHORUS THROUGH SANDY SOILS,
Mansell, R.S., Selim, H.M., Kanchanasut, P., Davidson, J.M., and Fiskell, J.G.A.
Florida University, Department of Soil Science, Gainesville, Florida.
Water Resources Research, Vol. 13, No. 1, p 189-194, February 1977. 8 fig,
2 tab, 24 ref.

Descriptors: *Phosphorus, *Soils, *Sands, *Path of pollutants, Laboratory tests, Model studies, Mathematical models, Phosphates, Phosphorus compounds, Adsorption, Chemical precipitation, Soil water movement, Leaching, Soil chemistry, Fertilizers, Pollutants, Water pollution.

Reversible equilibrium adsorption-desorption relationships were inadequate for describing the transport of orthophosphate through water-saturated and water-unsaturated cores from surface A sub 1 and subsurface A sub 2 horizons of Olsmar fine sand. Using a kinetic model with nonlinear reversible adsorption-desorption improved descriptions of phosphorus transport through these soils. Phosphorus effluent concentrations were described best by using an irreversible sink for chemical immobilization or precipitation with a nonlinear reversible kinetic adsorption-desorption equation.

77:05B-002
LYSIMETER AND FIELD MEASUREMENTS OF CHLORIDE AND BROMIDE LEACHING IN AN UNCULTIVATED LOAMY SAND,
Saffigna, P.G., Keeney, D.R., and Tanner, C.B.
Wisconsin University, Department of Soil Science, Madison, Wisconsin.
Soil Science Society of America Journal, Vol. 41, No. 3, p 478-482, May-June, 1977.
4 fig, 4 tab, 12 ref.

Descriptors: *Leaching, *Halides, *Lysimeters, *Chlorides, *Bromides, *Path of pollutants, Tracers, Dispersion, Soils, Soil water, Soil water movement, Solvents, On-site investigations, Drainage, Soil profiles, Soil physics, Soil science.

Field and lysimeter measurements were made of Cl and Br leaching in a Plainfield loamy sand at Hancock, Wisconsin. Chloride and Br were excellent companion tracers, moving in a 1:1 ratio through the 500-cm field profile to the water table even when differences in halide leaching occurred between adjacent sites. Half of the Cl or Br applied to the lysimeters was leached through the 125-cm lysimeter profile in 13 or 17 cm of drainage during 22- and 205-day experiments, respectively. Edge effects in the lysimeter were studied by applying Br near the edge and Cl in the center. Bromide was detected in the lysimeter drainage before Cl, but overall, edge effects were small. Lateral movement of Cl and Br in the lysimeter profile was less than 20 cm, which helps explain why large localized variations in solute transport can persist to considerable depth in this sandy soil. The differences in the distribution of halide between adjacent soil profiles within the lysimeter and field exceeded the average differences between the field and the lysimeter soil profiles.

77:05B-003
EFFECTS OF IRRIGATION MANAGEMENT ON THE QUALITY OF IRRIGATION RETURN FLOW IN ASHLEY VALLEY, UTAH,
Bliesner, R.D., Hanks, R.J., King, L.G., and Willardson, L.S.
Superior Farming Company, Bakersfield, California.
Soil Science of America Journal, Vol. 41, No. 2, p 424-428, March-April, 1977.
5 fig, 3 tab, 11 ref.

Descriptors: *Leaching, *Irrigation effects, *Utah, *Return flow, *Irrigation water, Salinity, On-site investigations, Sprinkler irrigation, Soil management, Alfalfa, Electrical conductance, Soil profiles, Lysimeters.

A study was conducted to evaluate reduced leaching fractions under different field water management conditions. Three qualities of water were applied at three leaching fractions to areas of an alfalfa (Medicago sativa L.) field having three depths to the water table. A sprinkler irrigation was used, with the electrical conductivity of the irrigation water and soil solution extract at various depths measured for each application. Results indicate that soil profile salinity is relatively unaffected by leaching fraction for short periods of time (1 to 2 years), due to high relative concentrations of calcium and sulfate in the irrigation water and soil solution. The electrical conductivity of waters applied averaged 0.98, 2.22 and 2.80 mmhos/cm, respectively, for the season. Leaching fractions for the low leaching treatment of each water quality averaged 0.003, with other treatments ranging from 0.082 to 0.343. The total amount of salt removed in irrigation return flow from such an area varies directly with drainage water quantity since the concentration is relatively constant.

77:05B-004
MODELING NITRATE MOVEMENT AND DISSIPATION IN FERTILIZED SOILS,
Saxton, K.E., Schuman, G.E., and Burwell, R.E.
Agricultural Research Service, Department of Hydraulic Engineering, Columbia, Missouri.
Soil Science Society of America Journal, Vol. 41, No. 2, p 265-271, March-April, 1977. 5 fig, 1 tab, 27 ref.

Descriptors: *Model studies, *Leaching, *Nitrates, *Iowa, *Path of pollutants, Water pollution sources, Solutes, Fertilizers, Movement, Soil profiles, Mathematical model, Agricultural watersheds, Soil water movement, Percolation, Soil moisture, Pollutants, Demonstration watersheds, Crops, Corn (field).

It is important to know the fate of nitrogen (N) fertilizers to ensure crop production and to avoid pollution, but frequent measurement of soil N is difficult. Therefore, a digital model was developed to calculate the occurrence, movement, and dissipation of nitrate-nitrogen (NO3-N) within the soil profile of fertilized agricultural lands. Daily NO3-N amounts and distributions within a 1.8-m soil profile were calculated by representing the major processes influencing NO3-N for the entire year. Daily soil moisture amounts and movement were predicted by a previously developed soil moisture-evapotranspiration model. Profiles of NO3-N measured periodically on two research watersheds in western Iowa, one normally fertilized (168 kg/ha per year) and the other excessively fertilized (448 kg/ha per year) with N, were used for model verification. The daily calculations for the fertilized cornfields with moderately permeable soils included NO3-N movement, dissipation, and profile leaching. The predicted NO3-N profiles closely represented those measured. Like most prediction methods, this one was developed to a state of utility, but revisions, improvements, and additions always are possible and desirable. Many of the model representations could be improved by including additional details and refinements. And some assumptions, like negligible denitrification, could be eliminated if proper representation were available.

77:05B-005
CHEMICAL QUALITY OF EFFLUENTS AND THEIR INFLUENCE ON WATER QUALITY IN A SHALLOW AQUIFER,
Purtymun, W.D., Buchholz, J.R., and Hakonson, T.E.
Los Alamos Scientific Laboratory, Los Alamos, New Mexico.
Journal of Environmental Quality, Vol. 6, No. 1, p 29-32, January-February, 1977. 2 fig, 4 tab, 5 ref.

Descriptors: *New Mexico, *Water quality, *Alluvial aquifers, *Waste water disposal, Effluents, Water pollution sources, Chemicals, Aquifers, Data collections, On-site investigations, Evaluation, Storm runoff, Hardness (water), Fluorides, Calcium, Carbonates, Sodium, Nitrates, Chlorides, Bicarbonates.

The chemical quality of liquid effluent released from an industrial waste treatment plant at the Los Alamos Scientific Laboratory controls the quality of water in a shallow aquifer in the alluvium of Mortandad Canyon. The dilution of the effluent with surface flow in the canyon reduces the concentrations of the chemicals as they move down gradient into the aquifer. Mass estimates of residual chemicals in solution in the aquifer average 1-6% of the total chemicals released to the canyon from 1963-1974. The average annual concentration of sodium, nitrate, chloride, and total dissolved solids in the aquifer through a 12-year period was directly correlated with annual average concentrations in the effluent. This relationship provides a means of predicting the impact of the chemical effluents on the quality of water in the aquifer. Chemical concentrations in solution in the aquifer have increased over prerelease levels; however, there has not been a steady accumulation of these materials in the water with time. The rapid loss of water and its associated chemicals from the aquifer prevents chemical accumulation and indicates that cessation of effluent release to the canyon would rapidly improve the quality of water in the aquifer.

77:05B-006
PERSISTENCE OF PROPANIL, DCA, AND TCAB IN SOIL AND WATER UNDER FLOODED RICE CULTURE,
Deuel, I.E., Jr., Brown, K.W., Turner, F.C., Westfall, D.G., and Price, J.D.
Texas Agricultural Experiment Station, College Station, Texas.
Journal of Environmental Quality, Vol. 6, No. 2, p 127-132, April-June, 1977. 6 fig, 3 tab, 14 ref.

Descriptors: *Pesticides, *Herbicides, *Irrigation, *Rice, Pollutants, Agricultural chemicals, Analytical techniques, Pesticide residues, Sprays, Leaching, Water pollution, Soil contamination, Water pollution sources, Pollutant identification, Water quality, Agronomy, Soil analysis, Water analysis.

Field experiments were conducted to determine the residue levels of propanil (3', 4' -dipropionanilide, DCA (3, 4-dichloroaniline), and TCAB (3, 3', 4, 4'-tetrachloroazobenzene) in the flood water and Beaumont clay soil under normal rice (Oryza sative L.) cultivation. Propanil applied as a foliar spray at 3.4 and 6.8 kg/ha 24 hours before flooding was dissipated from the flood water within 24 hours following the flood. The amount of propanil dissipated corresponded to the DCA concentration in the flood water at 24 hours, indicative of biological quantities. Neither propanil nor its metabilities were detected in soil samples collected at 2.5-5.0 cm and 17.5-20.0 cm below the surface 24 hours following the application of the flood water.

77:05B-007
EFFECT OF TEMPERATURE AND HYDROXY ALUMINUM INTERLAYERS ON THE ADSORPTION OF TRACE RADIOACTIVE CESIUM BY SEDIMENTS NEAR WATER-COOLED NUCLEAR REACTORS,
Elprince, A.M., Rich, C.I., and Martens, D.C.
Virginia Polytechnic Institute and State University, Department of Soils and Water, Blacksburg, Virginia.
Water Resources Research, Vol. 13, No. 2, p 375-380, April 1977. 3 fig, 1 tab, 38 ref.

Descriptors: *Cesium, *South Carolina, *Radioactive wastes, *Nuclear reactors, *Thermal pollutions, *Radioisotopes, Nuclear wastes, Water pollution sources, Radiochemical analysis, Water quality, Water pollution, Adsorption, Chemical properties, Expansive clays, Heat pollution, Water temperature, Physical properties, Sediments.

The adsorption of Cs137 by sediments from the Savannah River Plant follows a theoretically expected linear relationship between ln Kd and 1/T where Kd and T are the equilibrium distribution coefficient (Cs adsorbed, meg/g/Cs(+) in solution, meq/ml) and the temperature in kelvins, respectively. The slope of the plots decreases after removal of hydroxy Al interlayers with citrate pretreatment. Hydroxy Al interlayers thus make Cs(+) adsorption more temperature dependent. The thermal effect of hydroxy Al interlayers becomes more significant in sediments containing a swelling 2:1-2:2 intergrade clay mineral. The phenomenon was explained by considering hydroxy Al interlayers as a source of hydronium ions H30(-) which compete with Cs(+) for exchange positions in wedge zones. An increase in temperature favors an increase in H30(-) ions, which in turn favors less adsorption of Cs(+). Aside from the thermal effect, the positively charged hydroxy aluminum polymeric groups drastically decrease the cation exchange capacity and, consequently, the adsorption of cesium.

77:05B-008
SIMULATION OF TWO-DIMENSIONAL CONTAMINANT TRANSPORT WITH ISOPARAMETRIC HERMITIAN FINITE ELEMENTS,
van Genuchten, M.T., Pinder, G.F., and Frind, E.O.
Princeton University, Department of Civil Engineering, Princeton, New Jersey.
Water Resources Research, Vol. 13, No. 2, p 451-458, April 1977. 10 fig, 11 ref.

Descriptors: *Pollutants, *Soil contamination, *Model studies, *Mathematical models, Mathematical studies, Mathematics, Finite element analysis, Path of pollutants, Dispersion, Infiltration, Analytical techniques, Data processing, Groundwater movement.

A deformed isoparametric Hermitian element can be used in the simulation of two-dimensional contaminant transport. The degree of freedom arising from the cross derivative may be eliminated in the Galerkin-type finite element formulation, reducing the computational effort per node. Two example problems demonstrated that the Hermitian element gives results which are comparable to those obtained with the zero-order continuous cubic element but requires 25-40% fewer degrees of freedom, depending on the geometrical description of the problem.

77:05B-009
HERBICIDES FROM CROPPED WATERSHEDS IN STREAM AND ESTUARINE SEDIMENTS IN HAWAII,
Green, R.E., Goswami, K.P., Mukhtar, M., and Young, H.Y.
Hawaii University, Department of Agronomy and Soil Science, Honolulu, Hawaii.
Journal of Environmental Quality, Vol. 6, No. 2, p 145-154, April-June, 1977. 1 fig, 7 tab, 34 ref.

Descriptors: *Pesticides, *Herbicides, *Agricultural chemicals, *Pollutants, *Water quality, *Hawaii, Water pollution, Soil contamination, Agronomy, Soil analysis, Sugarcane, Sediments, Degradation (decomposition), Runoff, Phytoplankton, Marine biology, Analytical techniques, Path of pollutants.

Analysis of sediments and soils associated with two estuaries on Oahu was conducted to determine if herbicides used in plantation crops reach coastal waters. Analytical procedures were developed for simultaneous extraction of atrazine, ametryn, diuron, and DCA. Field soil and runoff samples from two small monitored watersheds provided additional information on the dissipation of diuron in sugarcane and pineapple fields, and on diuron removal in runoff waters. Atrazine and ametryn dissipated rapidly in field soils, and neither was found normally in stream and estuarine sediments. Diuron, on the other hand, was sufficiently persistent in soils and sediments to be found in nearly all sediment samples obtained at six month intervals at several sites for each estuary and its associated streams. Diuron in sediments was generally less than 500 ppb (oven-dry basis), but occasionally much higher concentrations were encountered at sites which were subject to localized contamination from spray equipment loading areas. Diuron appears to be transported in runoff waters principally in the solution phase rather than adsorbed on suspended solids. Estuarine waters (West Loch) contained 0.1 to 1 ppb diuron, while concentrations i runoff waters were several times higher. It is not known if the chronic low levels adversely affect the ecological balance of the estuary.

77:05B-010
NITRATE-N PERCOLATION THROUGH IRRIGATED SANDY SOIL AS AFFECTED BY WATER MANAGEMENT,
Smika, D.E., Heermann, D.F., Duke, H.R., and Bathchelder, A.R.
Agricultural Research Service, Akron, Colorado.
Agronomy Journal, Vol. 69, No. 4, p 623-626, July-August, 1977. 3 fig, 3 tab, 9 ref.

Descriptors: *Water management (applied), *Percolation, *Fertilizers, *Water pollution, *Nitrates, Nitrogen, Groundwater, Soil types, Sands, Irrigation effects, Irrigation systems, Sprinkler irrigation.

A study was conducted to determine the magnitude and difference in NO3N losses from two widely different but current farmer-used fertilizer management practices with scheduled irrigation systems on sandy soils. The experiments were conducted during three consecutive corn growing seasons on three irrigation systems in Colorado. Nitrate-N percolation losses were measured in water samples collected at 150 centimeters below the soil surface in vacuum extractors. The actual amount of NO3N that will move through the soil is proportional to the concentration of NO3N in the soil and the amount of water that moves through the soil. The movement of nitrogen fertilizer below the major root zone of corn grown on loamy fine sand soils can be kept very small with proper water and fertilizer management, thereby minimizing the NO3N pollution potential of the groundwater.

77:05B-011
QUALITY OF IRRIGATION RETURN FLOW FROM FLOODED RICE PADDIES,
Brown, K.W., Deuel, L.E., Turner, F.C., and Price, J.D.
Texas A & M University, Department of Soil and Crop Sciences, College Station, Texas.
Proceedings of National Conference on Irrigation Return Flow Quality Management, Colorado State University, Fort Collins, Colorado, p 153-166, May 16-19, 1977.
16 fig, 18 tab.

Descriptors: Irrigation, Return flow, Rice, Pesticides, Nutrients, Nitrates, Phosphates, Potassium, Fertilizers, Irrigation water.

A three year field and laboratory study was conducted to determine the quantity and quality of irrigation return flow from flooded rice culture. Both intermittent and continuous flow irrigation techniques were evaluated. Selected pesticides and nutrients were applied at recommended and excessive rates. The concentrations of nitrate, phosphate and potassium in the return flow were all within levels acceptable for drinking water. Only small amounts of the fertilizer applied to the soil before flood or in the floodwater were lost in the irrigation return flow. The large amounts of rainfall received each year diluted the salts in the flood water so that the salt load of irrigation return flow did not differ greatly from that of the irrigation water. Increases in the electrical conductivity of the floodwater resulted from the release of certain ions from the soil after fertilizer applications. These increases lasted for periods of 5-10 days.

77:05B-012
EVALUATION OF SURFACE IRRIGATION RETURN FLOWS IN THE CENTRAL VALLEY OF CALIFORNIA,
Tanji, K.K., Biggar, J.W., Miller, R.J., Pruitt, W.O., and Horner, G.L.
California University, Department of Land, Air and Water Resources, Davis, California.
Proceedings of National Conference on Irrigation Return Flow Quality Management, Colorado State University, Fort Collins, Colorado, p 167-173, May 16-19, 1977.
9 fig, 2 tab, 7 ref.

Descriptors: Variability, Return flow, Water quality, Water quality control.

The variability in the quantity and quality of surface return flows from two typical irrigation districts is reported for the 1975 and 1976 irrigation seasons. Factors contributing to such variations are noted. Emphasis is placed upon the concentration and mass emission of TDS and SS. The implications of these findings are discussed relative to Pl 92-500 and best management practices.

77:05B-013
MODELING SALT TRANSPORT IN THE IRRIGATED SOILS OF GRAND VALLEY,
Ayars, J.E., McWhorter, D.B., and Skogerboe, G.V.
Maryland University, Department of Agricultural Engineering, College Park, Maryland.
Proceedings of National Conference on Irrigation Return Flow Quality Management, Colorado State University, Fort Collins, Colorado, p 369-374, May 16-19, 1977.
6 fig, 1 tab, 6 ref, 2 equ.

Descriptors: Model studies, Simulation analysis, Colorado, Colorado river, Salinity, Saline soils, Saline water, Leachate, Return flow.

This study was undertaken to evaluate the effects of the volume of leachate leaving the soil profile on the quality of the leachate. A numerical salt transport model was selected for use in the study. Field data to calibrate the model were collected on 63 research plots located in the Grand Valley. The model was tested and calibrated with the field data and then used in a series of hypothetical simulations designed to provide the required information. The modeling results indicate that the salt concentration of the leachate is independent of the volume of leachate. The six-year simulation showed that the concentration of salt below the root zone was relatively constant. Therefore, the salt loading due to subsurface irrigation return flows can be calculated from a water budget analysis, with salt load reductions being directly proportional to the reduced volume of subsurface return flow.

77:05B-014
UPTAKE AND LOSSES OF 15N APPLIED TO ANNUAL GRASS AND CLOVER IN LYSIMETERS,
Jones, M.B., Delwiche, C.C., and Williams, W.A.
California University, Department of Agronomy and Range Science, Davis, California.
Agronomy Journal, Vol. 69, No. 6, p 1019-1023, November-December, 1977. 2 fig, 3 tab, 10 ref.

Descriptors: Nitrogen, Lysimeters, Fertilizers, Fertilization, Nutrients, Leaching, California, Denitrification.

The California annual grasslands comprise about one-third of the state, and they play a large role in the hydrology of most watersheds in central and northern California. Apparent recovery of applied N has been low, and a large percentage has been unaccounted for in N balance studies. The present experiment was done with 15N to determine the fate of applied N, especially that leached and that volatilized (by difference). Conclusions: There was modest leaching loss but essentially no gaseous loss from moderate rates of N applied to grass in February; recovery of fertilizer by clover was poor; and a single large application (500 kg N/ha) resulted in a substantial leaching and gaseous losses under both grass and clover.

77:05B-015
DEICING SALT MOVEMENT AND ITS EFFECTS ON SOIL PARAMETERS AND VEGETATION,
Buzio, C.A., Burt, G.W., and Foss, J.E.
Maryland University, Department of Agronomy, College Park, Maryland 20742.
Agronomy Journal, Vol. 69, No. 6, p 1030-1032, November-December, 1977. 3 fig, 1 tab, 13 ref.

Descriptors: Salts, Soils, Soil investigations, Soil properties, Chlorides, Salinity, Saline soils.

Salt damage to the environment occurs in restricted areas in humid regions as a result of factors such as industrial waste, sea water, and deicing salt. A study was conducted, therefore, to determine the distribution of salt leached from a deicing salt pile, and its effects on soil parameters (pH, Mg, P, and K) and plant successional changes in a hardwood forest area. Lateral movement and leaching of chloride was studied as it occurred in an adjacent slope by sampling the soil to a depth of 76 cm at 17 sites. The soil samples collected from the field were then analyzed for salt content by using the conductivity bridge. Lateral movement (of chloride) was extensive with subsequent leaching to a depth greater than 76 cm. Of the measured soil parameters, only K was found to be correlated with NaCl concentration. Within three years of the establishment of the salt stockpile, all the trees in the sampled area were dead. Out of 29 plant species found to have invaded the sites with less than 5,000 ppm of NaCl, only 10 were found in sites with concentrations greater than 15,000 ppm. Recommendations to be considered when establishing a deicing salt pile are presented.

77:05B-016
SOLUTE TRAVEL TIMES TO WELLS,
Kirkham, D., and Affleck, S.B.
Iowa State University, Department of Agronomy, Ames, Iowa.
Ground Water, Vol. 15, No. 3, p 231-242, May-June, 1977. 7 fig, 15 ref.

Descriptors: *Groundwater, *Solutes, *Groundwater movement, *Travel time, *Model studies, Mathematical models, Aqueous solutions, Nitrates, Wells, Water wells, Water pollution, Water pollution sources, Hydraulic conductivity.

Theoretical travel times were given for a solute to reach a well from an injection point for wells that fully penetrate confined aquifers of constant thickness and mainly constant conductivity and porosity. Solute is assumed to move along streamlines with the water in piston flow under steady flow conditions. Three cases were considered. (1) For a "standard" well of external radius of influence r sub e and well radius r sub w, the travel time varies approximately directly as the square of the distance r of the injection point from the well, as the ratio f/K of porosity to conductivity, and as ln r sub e/r sub w. (2) For a well in which the flow region is divided by radius r sub c into two regions, with the region next to the well clogged and of very low conductivity, K sub I, the travel time varies approximately directly as r squared, as f/K sub I, and as l n r sub c/r sub w. (3) For a well being fed from a line drive (river) at a distance d from the well, the travel time from a point on the line drive to the well varies as the distance d squared, as f/K, as l n 2d/r sub w, and as a function of the position of the point along the line drive. In each case, the travel time is inversely proportional to h sub e - h sub w, where h sub e is the head at the radius of influence r sub e (or at the line drive) and h sub w is the head at the well. In the three cases, doubling the pumping rate halves the travel time. Travel times can affect the extent of chemical changes of the solute (contaminant) during its flow to the well.

77:05B-017
NITRATE AND CHLORIDE IN GROUND WATER UNDER IRRIGATED AGRICULTURE IN CENTRAL WISCONSIN,
Saffigna, P.G., and Keeney, D.R.
Wisconsin University, Department of Soil Science, Madison, Wisconsin.
Ground Water, Vol. 15, No. 2, p 170-177, March-April, 1977. 3 fig, 4 tab, 18 ref.

Descriptors: *Nitrates, *Chlorides, *Groundwater, *Wisconsin, Agriculture, Irrigation, Return flow, Leachate, Fertilization, Potatoes, Beans, On-site data collections, Groundwater movement, Sampling, Water quality, Land management.

Results of this study indicated that the nitrate and chloride concentrations in the groundwater of the central Wisconsin sand plains are signficantly above background, and that the main source is the irrigated agriculture in the region. The study was conducted at three levels of intensity: a small field during one growing season, a University Experimental Farm over several years, and many local farms during part of a growing season. Differences in concentrations of nitrate-N and chloride in the surface of the groundwater underlying the moderately fertilized potato field closely reflected the fertilizer and irrigation management on different parts of the field during that season. This detailed study of one field showed that solute transit times through the 16 ft. (5 m) of unsaturated zone to the surface of the groundwater are less than a year. Differences in concentration of nitrate-N and chloride between irrigation wells on the Experimental Farm closely reflected the irrigation and fertilizer practices on surrounding fields. On a large scale, the nitrate-N and chloride concentrations in area farmer irrigation wells were as different between wells on the same farm as among the various farms.

77:05B-018
GROUNDWATER TURBIDITY RESULTING FROM ARTIFICIAL RECHARGE,
Nightingale, H.I., and Bianchi, W.C.
Agricultural Research Service, Fresno, California.
Ground Water, Vol. 15, No. 2, p 146-152, March-April, 1977. 8 fig, 1 tab, 21 ref.

Descriptors: *Groundwater, *Turbidity, *California, Groundwater recharge, Artificial recharge, Salinity, Wells, Groundwater movement, Hydrology, Aquifers, Aquifer testing, Laboratory tests, On-site investigations.

Turbid groundwater is rarely observed in domestic or public supply aquifers. At the Leaky Acres Recharge Facility at Fresno, California, water of low salinity (less than 50 micromhos/cm) and turbidity (less than 5 FTU, Formazin turbidity units) is recharged in the spreading basins. Six months after the start of the third (1973) recharge period, the groundwater salinity was decreased to about 100 micromhos/cm from the initial mean of 147 micromhos/cm, and the groundwater became visibly turbid (more than 5 FTU). Two months later, some peripheral domestic wells also began to become turbid. After two more recharge periods (1974 and 1975), turbidity at 10 observation wells beneath Leaky Acres averaged 18 FTU, and salinity averaged 74 micromhos/cm. By this time, groundwater turbidity in peripheral wells near Leaky Acres had decreased to less than 0.5 FTU. This turbidity was raced to poorly crystallized and extremely fine colloids, which have leached from the surface soils because of the low salinity of the recharge water. Laboratory and field studies showed that gypsum application will reverse the phenomena, but such treatment is uneconomical. This phenomenon is a transient one, and now turbidity outside the recharge area is insignificant from a water quality viewpoint. However, the magnitude of the mass of material in transit through the profile if stabilized through flocculation or sieving in soil pore space, could greatly change the water transmission and so recharge project performance. However, this effect has not yet been noted at Leaky Acres.

77:05B-019
AN INTEGRATED APPROACH TO DELINEATING CONTAMINATED GROUND WATER,
Berk, W.J., and Yare, B.S.
Berk and Ciaramella, Cranbury, New Jersey.
Ground Water, Vol. 15, No. 2, p 138-145, March-April, 1977. 5 fig, 3 tab, 6 ref.

Descriptors: *Groundwater, *Water pollution sources, *Atlantic coastal plain, *Groundwater movement, Observation wells, Groundwater recharge, Water pollution, Hydrogeology, Sodium chloride, Aquifers, Hydrology.

Disposal of industrial process water into an unlined lagoon in permeable Atlantic Coastal Plain sediments resulted in a groundwater contamination problem caused by infiltration of the process water into a major unconfined aquifer which underlies the lagoon at shallow depth. Most of the area water supply wells terminate in this formation. Before this disposal method was discontinued, traces of the process water appeared in nearby wells. Because of the relatively large area and depths involved, as indicated by preliminary data, delineation of the distribution of contaminant within the aquifer through a systematic well drilling program posed a significant economic problem. To keep costs within a reasonable range, a resistivity survey program was implemented to obtain information on the gross distribution of the contaminant and to provide data for the selective location of monitor wells. Eight wells were constructed to obtain samples of the groundwater in order to measure contaminant concentrations and to verify the interpretations of areal contaminant distribution inferred from the resistivity data. The groundwater sampling procedure developed during this investigation was described. The combination of the resistivity survey with the groundwater sampling procedure developed during this investigation proved to be a valuable and reliable technique for delineating in three dimensions a contaminant body within an aquifer in unconsolidated sediments. Utilization of the resistivity survey data to selectively locate the monitor wells and to define the lateral extent of the contamination increased the efficiency of the investigation and significantly reduced the cost of the program.

77:05B-020
WATER QUALITY VARIATIONS FOR PUMPING WELLS,
Schmidt, K.D.
Groundwater Quality Consultant, Fresno, California.
Ground Water, Vol. 15, No. 2, p 130-137, March-April, 1977. 7 fig, 9 ref.

Descriptors: *Groundwater, *Water quality, *Monitoring, *California, *Water wells, Water pollution, Nitrates, Shallow wells, Alluvial aquifers, Fluctuations, Variability, Sampling, Water sampling, Seasonal, Water supply, Pumping.

Past groundwater quality monitoring programs have often involved sampling of low-capacity wells near point or line sources of recharge or pollution. However, large-capacity wells produce much of the groundwater pumped for municipal, industrial, and agricultural uses. Short-term, seasonal, and long-term fluctuations in quality are common for water pumped from many large-capacity wells. In many cases, there is a considerable difference between in-situ "groundwater quality" and the quality of water sampled at the well discharge. Short-term pump tests for several municipal wells in the San Joaquin Valley, California, indicated that nitrate concentrations decreased exponentially with pumping time. Variability in pump operation creates substantial short-term changes in well water quality. Short-term changes are most evident for infrequently pumped, shallow wells near point or line sources of recharge or pollution. Seasonal changes in quality have been documented for water from wells in areas of diffuse sources of pollution, such as agricultural return flow and septic tanks. These changes are due primarily to significant changes in depth to water and vertical hydraulic head gradient. Once the short-term and seasonal trends are established, the optimal sampling approach can be determined in order to establish long-term trends.

77:05B-021
QUANTIFYING THE NATURAL FLUSHOUT OF ALLUVIAL AQUIFERS,
Fryberger, J.S., and Bellis, W.H.
Engineering Enterprises, Inc., Norman, Oklahoma.
Ground Water, Vol. 15, No. 1, p 58-65, January-February, 1977. 6 fig, 7 ref.

Descriptors: *Alluvial aquifers, *Groundwater, *Water pollution, *Model studies, Mathematical models, Water quality, Salinity, Salts, Precipitation (atmospheric), Flow, Groundwater movement, Base flow, Alluvium, Evapotranspiration, Evaporation, Pollutants, Path of pollutants, Forecasting, Pollution.

A plume of contaminated water may extend downstream for several miles in an alluvial aquifer. Hydrologic forces acting on the aquifer generally tend to dilute the contaminant downstream from the source. After the pollution has been stopped, how rapidly will these hydrologic forces flush out the contaminant. The answer to this question may be calculated by using the mass-balance equation herein developed. This described mass-balance mathematical model incorporates all the hydrologic forces acting on the alluvial aquifer that affect the concentration of the contaminant. Methods were presented to define and quantify each of the hydrologic forces. These forces include: (1) present quantity and quality (with respect to contaminant) of water in the alluvium and the change in the quality downstream, (2) quantity and quality of groundwater inflow, (3) quantity and quality of flood inflow, (4) quantity and quality of base flow, (5) quantity of recharge from precipitation, and (6) quantity of loss from evapotranspiration. The equation was first balanced to agree with past conditions and observed field data, and it was then used to predict future quality changes after the pollution is stopped. The method is applicable primarily to situations in which the pollution has been taking place over a long period of time and the water quality in the alluvium has reached equilibrium at any given point. Modifications may be possible to permit use of the general approach to short-term of slug-type pollution events.

77:05B-022
PROBLEMS OF HEAT STORAGE IN AQUIFERS,
Werner, D., Kley, W.
Eidgenoessische Technische, Zurich (Switzerland).
Journal of Hydrology, Vol. 34, No. 1/2, p 35-43, July 1977. 3 fig, 7 ref.

Descriptors: *Thermal pollution, *Storage, *Heated water, *Aquifers, On-site investigations, Model studies, Mathematical models, Underground storage, Heat transfer, Diffusion, Convection, Temperature, Groundwater, Powerplants, Nuclear powerplants, Wells, Injection wells.

A hydrothermic field experiment near Krefeld (Federal Republic of Germany) was used to study the propagation of heat in groundwater. For two months, water at a temperature of 45 C was fed through a well pipe to the water-bearing strata, the distribution of temperature in the surrounding space was measured, and its variation with time was observed. A theoretical model was developed to simulate the field experiment. The model consisted of a time-spaced differential method with the help of which good conformity between theory and experiment was obtained. The aim of the study was to ascertain the physical bases for the storage of heat in groundwater. The technoeconomic and environmental problem was posed because of the enormous quantities of cooling water necessary in the operation of atomic power stations. A functional theoretical model can help to decide how far the idea of storing heat in an aquifer is technically feasible.

77:05B-023
INTERFACIAL REACTIONS AND THE FATE OF HEAVY METALS IN SOIL-WATER SYSTEMS,
Huang, C.P., Elliott, H.A., and Ashmead, R.M.
Delaware University, Newark, Delaware.
Journal Water Pollution Control Federation, Vol. 49, No. 5, May 1977, p 745-756. 8 fig, 1 tab, 32 ref.

Descriptors: *Water pollution sources, *Heavy metals, Interfaces, Earth-water interfaces, Chemistry, Adsorption, Chemical precipitation, Soil chemistry, Solubility.

The processes and factors that govern the fate of heavy metals in the soil-water system are identified as dissolution-precipitation and adsorption. The congruent and incongruent solubility of oxides, hydroxides, sulfates, sulfides, and carbonates of heavy metals contributes to the chemical constituents of soil-water. The process is influenced by pH, redox potential, the amount of carbonate and sulfur present and the presence of organic substances. The formation of metal-chelates or metal complexes can render metal solids more soluble. Microorganisms, whose metabolic activities tend to modify the redox potential and contribute organic acids can influence the solubility of metal solids. Interfacial association between heavy metals and soil minerals is considered the most important process in regulating the concentration of heavy metals in the soil-water environment. Copper and zinc are more removable than lead and cadmium. When the solid surfaces are very positively charged, positive lead and cadmium ions are expelled away from the interface and result in an excess of metal ions in the bulk phase of the soil-water system.

77:05B-024
RELATION OF CLIMATE TO LEACHING OF SOLUTES AND POLLUTANTS THROUGH SOILS,
Tanner, C.B.
Wisconsin University, Department of Soil Science, Madison, Wisconsin.
Final Report to NOAA, Environmental Data Service, May 20, 1977. 39 p, 9 fig, 9 tab.

Descriptors: *Soil water movement, *Pollutants, *Climates, *Nitrates, *Leaching, *Path of pollutants, Soil physics, Groundwater, Evapotranspiration, Irrigation, Water pollution sources, Soil contamination.

The original study had two objectives: (1) To test whether a simple soil physics model of nitrate leaching could be combined with analysis of weather records to model nitrate movement to the water table. This embraces both the concentration distributions in the soil and the total flux. Leaching is greatest when heavily fertilized and irrigated crops are grown on sandy soils. (2) The second objective was to determine whether the leaching information could be used to improve irrigation and fertilizer management to minimize leaching and improve management efficiency of crops where nitrogen and irrigation are used intensively.

77:05B-025
COMPLETION REPORT ON CONTRIBUTION OF FERTILIZERS TO WATER POLLUTION,
Douglas, L.A., and Bourodimos, E.L.
Rutgers, Department of Soils and Crops, New Brunswick, New Jersey.
Completion Report, Water Resources Research Institute, Rutgers University, New Brunswick, New Jersey, July 1977. 8 p, 3 ref.

Descriptors: *Nitrates, *Nitrites, *Ammonia, *Phosphates, *Leaching, *Fertilizers, Land use, Denitrification, Water pollution sources, Path of pollutants.

Field studies were undertaken to determine the magnitude of leaching of fertilizer NO3, NH4, and PO4. The effect of N-serve on these reactions was observed, and little effect on leaching was found because most leaching takes place during the fall and winter when precipitation exceeds evapotranspiration. No leaching takes place during the fall and winter when precipitation exceeds evapotranspiration. No leaching of NH4 and PO4 was observed. The common fertilizer efficiency measure of N in crop/N applied in fertilizer may be used as an indication of the amount of fertilizer N that will be leached. Studies of nutrients in streams were undertaken to relate land use to NO3, NH4 and PO4 concentrations in surface waters. Sewage treatment plants and "illegal drains" were found to be major sources of all three ions. In order of decreasing contribution of NO3: urban land contributes more than cropland which contributes more than woodlands. Urban lands, croplands and woodlands contribute equal amounts of NH4 and PO4 to streams. The "background level" of PO4 in central New Jersey streams is many times higher than the 0.01 ppm level often advocated. Although very high concentrations of NO3 were found in the soil solution in the subsoil the concentration of NO3 found in streams was rather low. Denitrification must be an active process in subsoils, and probably in the groundwater. Groundwater studies were also undertaken, but they were inconclusive.

77:05B-026
SIMULATION OF NUTRIENT LOADINGS IN SURFACE RUNOFF WITH THE NPS MODEL,
Donigian, A.S., Jr., and Crawford, N.H.
Hydrocomp, Incorporated, Palo Alto, California.
EPA Report No. 600/3-77-065, June 1977. 110 p, 30 fig, 8 tab, 24 ref, 3 append.

Descriptors: *Organic loadings, *Storm water, *Mathematical models, *Nutrients, *Urban runoff, Computer models, Phosphorus, Nitrogen, Iron, Suspended solids, Monitoring, Waste water treatment.

The Nonpoint Source Pollutant Loading (NPS) Model was evaluated for simulation of nutrient loading in surface runoff with one urban and two small agricultural watersheds. The NPS model was used to simulate total solids, total Kjeldahl nitrogen, total phosphorus, and iron for storm runoff over an 18-month period. Phosphorus, total nitrogen, and iron values predicted by the model compared favorably with observed values. Other parameters such as ammonia nitrogen, nitrate nitrogen, and phosphate phosphorus, which are transported in solution rather than in the sediment fraction of surface runoff, were not predicted as accurately. The NPS model is suggested as an adequate means of simulating nutrient loadings on the basis of sediment loss. Application of the model may be limited if subsurface flow in the area being considered is a major portion of total runoff.

77:05B-027
ENVIRONMENTAL MODEL OF KISSIMMEE RIVER BASIN,
Bedient, P.B., Huber, W.C., and Heaney, J.P.
Rice University, Department of Environmental Science and Engineering, Houston, Texas.
Journal of the Water Resources Planning and Management Division, American Society of Civil Engineers, Vol. 103, No. WR2, Proceedings Paper 13326, p 241-256, November 1977. 10 fig, 2 tab, 13 ref, 2 append.

Descriptors: *Runoff, *Drainage, *Florida, *Model studies, *Path of pollutants, Mathematical models, Water quality, Flood control, Land use, Water pollution, Pollutants, Phosphorus, Rivers, Lakes, Watersheds (basins), Hydrographs, Hydrology.

A hydrologic land-use model was developed and applied to the Kissimmee River Basin, Florida. Surface runoff quantity and quality were estimated for changing land-use and drainage patterns in order to explain hydrologic and water quality response along the river. The hydrologic model (HLAND) was based on a daily water balance for each soil land-use type in the watershed. Predicted runoff was routed down the river and compared to measured outflow hydrographs. Phosphorus loading rates were calculated using measured concentrations of total P and predicted runoff volumes. Observed concentrations and loading rates from tributaries along the river correlated well with the drainage density index, defined as the length of drainage network per unit area of watershed. Results indicated that greatest potential for control of runoff quantity and quality exists in on-site storage in marsh, pond, and lake areas.

77:05B-028
INTERACTIVE EFFECT OF SALINITY AND PHOSPHORUS ON SESAME,
Cerda, A., Bingham, F.T., and Hoffman, G.J.
California University, Department of Soil and Environmental Science, Riverside California 92521.

Soil Science Society of America Journal, Vol. 41, No. 5, p 915-918, September-October, 1977. 3 fig, 3 tab, 12 ref.

Descriptors: Salinity, Phosphorus, Crop response, Salts, Salt tolerance.

A solution culture experiment was conducted with a short-season sesame to observe interactive effects of osmotic potential, and P concentration on water relations, mineral nutrition, and yield characteristics. Salinity reduced yields linearly with a 50% decrease in pod yield at an osmotic potential of approximately -2.7 bars. Increasing P concentrations increased yields only at low salinity levels; at higher salinity levels, yields decreased progressively as P increased. Salt tolerance was reduced by the higher P additions.

77:05B-029
SIMULATION OF NUTRIENT LOSSES FROM CROPLAND,
Tubbs, L.J., and Haith, D.A.
Cornell University, Department of Agricultural Engineering, Riley-Robb Hall, Ithaca, New York 14853.
Presented at the 1977 Winter Meeting of the American Society of Agricultural Engineers, December 13-16, 1977, Chicago, Illinois, p 1-34. 17 fig, 14 tab, 34 ref, 38 equ.

Descriptors: Model studies, Nitrogen, Phosphorus, Runoff, Hydrogen, Nutrients, Infiltration, Simulation analysis.

A mathematical model has been developed to predict losses of nitrogen and phosphorus in cropland runoff and percolation water. The model is based on daily hydrologic and monthly soil nutrient balances. The model does not require calibration and has been validated using data from monitored field plots. Reasonable predictions of annual losses are obtained for dissolved inorganic nitrogen in runoff and percolation and dissolved inorganic phosphorus in runoff. Seasonal variations are well predicted for nitrogen but not for phosphorus.

77:05B-030
TILLAGE SYSTEM EFFECTS ON RUNOFF WATER QUALITY: SEDIMENTS AND NUTRIENTS,
Johnson, H.P., Baker, J.L., Shrader, W.D., and Laflen, J.M.
Iowa State University, Department of Agricultural Engineering, Ames, Iowa 50011.
Presented at the 1977 Winter Meeting, American Society of Agricultural Engineers, December 13-16, 1977, Palmer House Hotel, Chicago, Illinois, p 1-15. 2 fig, 3 tab, 9 ref.

Descriptors: Corn, Nitrogen, Erosion, Soil erosion, Phosphorus, Soil conservation, Water quality, Sediments, Nutrients.

Three tillage systems were utilized for growing corn on six paired small watersheds. The tillage systems retained a range of residue cover on the soil varying from about three to forty-five percent. Most of the nitrogen losses were associated with erosion. Soluble phosphorus losses were greatest with conservation tillage. Surface residue reduced markedly the soil losses.

77:05B-031
A HAZARD OF SUBDIVIDING FARMLAND,
Whitlock, W.W., Jr.
Harford County Health Department, BelAir, Maryland.
Ground Water, Vol. 15, No. 6, p 416-419, November-December, 1977. 2 fig, 4 ref.

Descriptors: *Groundwater, *Water quality, *Nitrates, *Maryland, Wells, Water wells, Farms, Farm wastes, Land use, Urbanization, Suburban areas, Nitrogen, Sampling, On-site data collections, Water chemistry, Hazards, Public health, Pollutants, Water pollution.

Changing land-use patterns are occurring in all areas of the United States, especially those surrounding urban centers. Previously farmed land is being converted to residential subdivisions of 1/4 to 1/2 acre lots with on-site water supply and sewage disposal systems (well and septic). This in itself can also cause hazards resulting from the original uses of the land that have not been anticipated. This paper was concerned with the high nitrate nitrogen levels in groundwater resulting from long-term farming. Natural chemicals and biological activity will break down manure to persistent nitrate that is then leached into the water table. Subsequent subdivision of the land, well installation, and consumption of the contaminated groundwater constitute a problem that has been recognized medically since 1945, but not by the drilling industry or environmental health personnel. Regulations of the Maryland State Department of Health and Mental Hygience provide for a required series of bacteriological and chemical samples prior to the water supply being put into service. To date, the tests usually are conducted after occupancy, if at all. In Harford County, Maryland, at least 4 subdivisions have been shown to have areas of excessive nitrate nitrogen (up to 60 ppm) showing the need for stringent enforcement of existing regulations.

77:05B-032
RETENTION AND LEACHING OF NUTRIENTS IN A LIMED ULTISOL UNDER CROPPING,
Juo, A.S.R., and Ballaux, J.C.
International Institute of Tropical Agriculture PMB 5320, Ibadan, Nigeria.
Soil Science Society of America Journal, Vol. 41, No. 4, p 757-761, July-August, 1977. 3 fig, 6 tab, 15 ref.

Descriptors: Maize, Leaching, Nutrients, Greenhouses, Soils, Soil investigations, Crop response, Crop production.

The response of maize to liming and the retention and leaching of Ca and other nutrient ions were studied in the greenhouse using an acid Ultisol from southern Nigeria. The soil was limed to various pH levels and maize was grown for 10 weeks. The largest growth response occurred when the soil pH was raised from 4.3 to 5.0 by liming (1.3 metric ton/ha). The highest yield was obtained when the soil pH was between 5.5 to 6.0.

77:05B-033
PHYSICAL AND CHEMICAL PARAMETERS AFFECTING TRANSPORT OF CS IN ARID WATERSHEDS,
McHenry, J.R., and Ritchie, J.C.
United States Department of Agriculture, Agricultural Research Service, Sedimentation Laboratory, Oxford, Mississippi.
Water Resources Research, Vol. 13, No. 6, p 923-927, December 1977. 6 tab, 8 ref.

Descriptors: Watersheds, Watershed management, Soils, Sediments, Sedimentation, Nitrogen, Rainfall, Cation exchange.

The occurrence and amount of fallout 137Cs were determined in 12 watersheds in the arid southwestern United States. The factors believed to influence the distribution of 137Cs in the watershed soils and in the reservoir sediments were investigated by using stepwise regression techniques. Seventeen parameters, in the case of soils, and 21 parameters, in the case of sediments, were used in the study. Ninety percent of the variation in the 137Cs content of soils, per unit weight, could be predicted in terms of the percentage of soil nitrogen, the R factor (rainfall intensity) of the universal soil loss equation, the percentage of sand in the soils, and the soil cation exchange capacity.

77:05B-034
MOVEMENT OF THREE HERBICIDES IN A FINE SAND AQUIFER,
Schneider, A.D., Wiese, A.F., and Jones, O.R.
United States Department of Agriculture, Agricultural Research Service, Bushland, Texas 79012.
Agronomy Journal, Vol. 69, No. 3, p 432-436, May-June, 1977. 8 fig, 1 tab, 9 ref.

Descriptors: Groundwater, Water pollution, Water quality, Herbicides, Aquifers, Sampling, Hydrodynamics.

In order to determine movement of farm chemicals that might accidentally contaminate underground water supplies, low concentrations of three herbicides and $NaNO_3$ as a tracer were injected into a sand aquifer through a dual-purpose well. Herbicides used were picloram, atrazine, and trifluralin. Recharge by injection continued for 10 days at an average rate of 81.8 cu m/hour. After a 10-day pause, the well was pumped for 12 days to determine if the herbicides and tracer could be recovered. Water samples were pumped from observation wells located 9, 20, and 45 m from the dual-purpose well. Herbicides were detected in the 9- and 20-m distant wells, but none of the herbicides or the tracer was detected in the 45-m distant well.

77:05B-035
RESIDUAL NITRATE AND MINERALIZABLE SOIL NITROGEN IN RELATION TO NITROGEN UPTAKE BY IRRIGATED SUGARBEETS,
Stanford, G., Carter, J.N., Westermann, D.T., and Meisinger, J.J.
Agricultural Environmental Quality Institute, Beltsville, Maryland 20705.
Agronomy Journal, Vol. 69, No. 2, p 303-308, March-April, 1977. 4 fig, 6 tab. 12 ref.

Descriptors: Sugar beets, Idaho, Nitrogen, Fertilizers, Fertilization, Irrigation, Soil water, Mineralization, Temperatures, Soil moisture.

Previously reported studies on N fertilization of sugarbeets in southern Idaho revealed considerable variation among sites in amounts of residual soil NO3 and N mineralized during short-term laboratory incubations. Consequently, the amount of N fertilizer needed to achieve near-maximum yields of sucrose differed markedly. The purpose of this study was to determine the feasibility of estimating amounts of N mineralized in the root zone during the season, taking into account site variations in temperature and soil water regimes. Residual soil NO3(-)-N and mineralizable N to approximate rooting depth were estimated for 21 field sites in 1971 and six sites in 1972. The relative contributions of these two N sources to total N uptake by the crop, in the absence of applied fertilizer N, were then assessed.

77:05B-036
SEASONAL ANHYDROUS AMMONIA COMPARISON FOR CORN WITH AND WITHOUT A NITRIFICATION INHIBITOR,
Boswell, F.C.
Georgia University, Department of Agronomy, College of Agricultural Experiment Stations, Georgia Station, Experiment, Georgia.
Agronomy Journal, Vol. 69, No. 1, p 103-106, January-February, 1977. 6 tab, 21 ref.

Descriptors: Ammonia, Corn, Nitrification, Nitrogen, Crop production, Leaching.

With increased interest in "off-season" N application and emphasis on better management of N with respect to environmental pollution and economic considerations, information is needed relative to seasonal anhydrous ammonia comparisons for corn with and without an inhibitor. Field studies compared rates of N applied preplant with December application either with or without the nitrification inhibitor, N-SERVE, to corn on a Coastal Plain soil. The nitrification inhibitor did not affect yield, number of ears, average ear weight, and percent N, P, K, Ca, and Mg in the tissue or concentrations of various other elements in tissue sampled early in the growing season, at early silking, or in corn grain. Both low (90 kg/ha) and high (180 kg/ha) N levels increased yields above check plots (zero N) when applied in December for the three-year average but both levels were significantly less than the high N level applied preplant.

77:05B-037
QUALITY OF IRRIGATION WATER AND SURFACE RETURN FLOWS FROM SELECTED AGRICULTURAL LANDS IN NEVADA DURING THE 1974 IRRIGATION SEASON,
Miller, W.W., Guitjens, J.C., and Mahannah, C.N.
Nevada University, Max C. Fleischmann College of Agriculture, Reno, Nevada.
Journal of Environmental Quality, Vol. 6, No. 2, p 193-200, April-June, 1977. 6 fig, 3 tab, 26 ref.

Descriptors: Return flow, Water quality, Irrigation water, Nevada, Water quality control, Tailwater, Phosphorus, Pollutants.

Agriculture has been identified as a major contributor of pollutants to surface waters. The purpose of this investigation was to gain knowledge of pollutants and pollutant loads carried in surface return flows to receiving waters. Information of this nature is needed by those agencies having administrative responsibility for water quality control. Quantitative and qualitative measurements of irrigation applications (head water) and surface return flows (tailwater) were conducted on four sites at three locations in the Carson Valley area of Nevada to investigate the change in pollutant loads of surface waters entering the leaving agricultural units. Dissolved oxygen (DO), biochemical oxygen demand (BOD), total dissolved solids (TDS), NO3(-)N, PO4(-)P, SO4, and turbidity were considered as major constituents of water quality. Concentrations were combined with flow volumes to compute the constituent loading per irrigation and net infiltrated amounts or seasonal contributions in the surface return flow. Phosphorus and BOD were found to be the major agricultural pollutants contributed by irrigation surface return flows. New infiltrated amounts of TDS, NO3(-)N, and other soluble constituents were recorded. Dissolved oxygen concentrations in head and tailwaters were found to be critically low. River standards for DO might be better expressed as a maximum permissible dissolved oxygen deficit for water at a given temperature carrying a given amount of BOD. Additional investigations should be undertaken to delineate possible interactions among pollutant constituents. Water quality variations of individual samples should be expressed in statistical terms so that it is possible to identify pollutant interdependencies and to establish an optimized sampling frequency.

77:05B-038
A STEADY-STATE CONCEPTUAL NITROGEN MODEL FOR ESTIMATING NITROGEN EMISSIONS FROM CROPPED LANDS,
Tanji, K.K., Fried, M., and Van De Pol, R.M.
Food and Agriculture Organization, International Atomic Energy Agency, Vienna, Austria.
Journal of Environmental Quality, Vol. 6, No. 2, p 155-159, April-June, 1977.
2 fig, 5 tab, 5 ref, 1 append, 40 equ.

Descriptors: Nitrogen, Model studies, Leaching, Corn, Crop production, Fertilizers, Fertilization.

Details of a conceptual nitrogen model are presented. The model is based upon the principles of mass balance and steady state. It considers both water and N flows into and out of the crop root zone. Illustrative computations are given for estimating steady-state N leaching losses from two cornfield sites and comparisons are made with measured values. This model may be applied to other crops or cropping practices.

77:05B-039
LYSIMETER MEASUREMENTS OF NITRATE AND CHLORIDE LOSSES FROM SOIL UNDER CONVENTIONAL AND NO-TILLAGE CORN,
Tyler, D.D., and Thomas, G.W.
Kentucky University, Lexington, Kentucky 40506.
Journal of Environmental Quality, Vol. 6, No. 1, p 63-66, January-March, 1977.
6 fig, 15 ref.

Descriptors: Lysimeters, Nitrates, Chlorides, Corn, Soils, Soil investigations, Soil water movement, Leaching, Salts, Nitrogen, Mulching.

Salt and water movement was studied using steel pan lysimeters in the field under corn grown in killed sod and with conventional tillage. The study was done to determine the actual leaching losses of nitrogen under the two tillage systems. Losses of nitrate nitrogen and chloride used as a tracer of nitrate ion were higher under the no-tillage system as measured in the leachate collected after rainfall. This loss could occur within 1 to 2 months after the application of the nitrogen. Concentrations of nitrate and chloride ions in the leachate indicated that these mobile, surface-applied anions could be washed into natural soil cracks and channels and flow much deeper into the soil than predicted by miscible displacement theory.

77:05B-040
PREDICTING EFFECTS OF SULFURIC ACID ON QUALITIES OF IRRIGATION AND DRAINAGE WATERS IN CALCAREOUS SOILS,
Miyamoto, S.
Texas A & M University Agricultural Research Center, 1380 A and M Circle, El Paso, Texas 79927.
Journal of Environmental Quality, Vol. 6, No. 1, p 12-18, January-March, 1977.
3 fig, 4 tab, 24 ref.

Descriptors: Sulfuric acid, Calcareous soils, Irrigation water, Drainage water, Water quality, Simulation analysis, Model studies.

Considerable quantities of sulfuric acid are being utilized in the southwestern United States for soil and water treatment. Future acid production may exceed demand and thus require disposal in some manner. Acid application or disposal to soils and water raises a question concerning effects on water quality. A numerical method is thus presented for predicting the effects of H_2SO_4 on qualities of irrigation and drainage waters, excluding trace elements, in calcareous systems. The method is based on known relations between ion equilibria and the solubility of calcite, magnesite, and gypsum. Computed results are presented for acid applied to waters or to soils under several hypothesized conditions, and compared with some reported laboratory or lysimeter data. Results indicate: (1) the numerical method is a promising tool, but requires further experimental verification; (2) acid effects on water quality depend strongly on CO_2 partial pressure and properties of soils and water, besides application rates; and (3) the assumption that acid application produces equivalent amounts of soluble salts is an oversimplification.

77:05B-041
FERTILIZER AND PESTICIDE MOVEMENT FROM CITRUS GROVES IN FLORIDA FLATWOOD SOILS,
Mansell, R.S., Calvert, D.V., Stewart, E.H., Wheeler, W.B., and Rogers, J.S.
Florida University, Gainesville, Florida 32611.
Publication No. EPA-600/2-77-177, August 1977. 133 p, 73 fig, 35 tab, 53 ref.
1 append.

Descriptors: Fertilizers, Fertilization, Pesticides, Florida, Soil properties, Irrigation water, Water quality, Soil management, Soil moisture, Soil water.

Concentrations and discharge amounts of NO_3-N, PO_4-P, 2, 4-D herbicide, terbacil herbicide, and chlorobenzilate acaricide were determined in surface and subsurface drainage waters from a citrus grove located in an acid, sandy flatwood soil of southern Florida. The citrus grove received routine applications of fertilizer, pesticide, and irrigation water as needed.

77:05B-042
RELATIVE MOVEMENT OF BROMIDE AND NITRATE IN SOILS UNDER THREE IRRIGATION SYSTEMS,
Onken, A.B., Wendt, C.W., Hargrove, R.S., and Wilke, O.C.
Texas A & M University Agricultural Research and Extension Center, Lubbock, Texas.
Soil Science Society of America Journal, Vol. 41, No. 1, p 50-52, January-February, 1977. 4 fig, 4 ref.

Descriptors: Bromides, Nitrates, Soils, Soil properties, Corn, Irrigation, Irrigation practices, Irrigation effects, Furrow irrigation, Sprinkler irrigation, Surface irrigation, Anions, Leaching, Fertilizers, Irrigation water.

Bromide has desirable characteristics as an indicator of nitrate movement in soils, although it has not been tested under field conditions. We studied its field applicability by growing sweet corn on plots to which a mixture of sodium nitrate and sodium bromide were band applied. Irrigation was accomplished by either furrow, sprinkler or subirrigation. Nitrate and $Br^{(-)}$ moved together in the soil profile, but the concentration of $NO_3^{(-)}$ and $Br^{(-)}$ were quantitatively unrelated. The lack of a quantitative relationship was probably due to (1) $NO_3^{(-)}$-N was the sum of that already present, that from mineralization of organic matter, plus that applied while bromide came only from that applied, and (2) $NO_3^{(-)}$-N from all three of these sources and $Br^{(-)}$ were removed from the soil at different rates by the growing crop.

77:05B-043
FIELD MEASUREMENTS OF AMMONIA VOLATILIZATION FROM SURFACE APPLICATIONS OF AMMONIUM SALTS TO A CALCAREOUS SOIL,
Hargrove, W.L., Kissel, D.E., and Fenn, L.B.
Texas Agricultural Experiment Station, P.O. Box 748, Temple, Texas 76501.
Agronomy Journal, Vol. 69, No. 3, p 473-476, May-June, 1977. 1 fig, 2 tab, 16 ref.

Descriptors: Ammonium, Ammonium salts, Soils, Soil investigations, Calcareous soils, Nitrogen, Fertilizers, Fertilization.

Many laboratory experiments have been conducted to study ammonia volatilization from N fertilizers, but few experiments have been conducted under field conditions. The objective of this study was to evaluate ammonia volatilization in the field from ammonium sulfate and ammonium nitrate applied to the surface of a calcareous soil. Houston Black Clay, that belongs to the fine, montmorillonitic, thermic family of Udic Pellusterts. Volatilization was evaluated indirectly by measuring N uptake by Coastal bermudagrass and directly by measuring ammonia as it volatilized. In the field plot study, estimated losses ranged from 3 to 10% of the applied N for ammonium nitrate, from 36 to 45% of the applied N for pelleted ammonium sulfate, and from 25 to 55% of the applied N for liquid ammonium sulfate at rates of 140 and 280 kg N/ha.

77:05B-044
THE WELLTON-MOHAWK: WHERE NECESSITY IS TEACHING THEM TO SAVE WATER,
Ross, R.
Irrigation Age, Vol. 11, No. 8, p 30, May-June, 1977. 1 fig.

Descriptors: Water conservation, Irrigation effects, Salinity, Saline water, Mexico.

In 1973, an agreement was signed between Mexico and the United States that could have far reaching influences on how southwestern American farmers irrigate. Leaders of the two nations signed documents which said that by a given date, the level of salts in the Colorado River, as it enters Mexico, would be held to certain "reasonable" limits. Reaching those limits will require new irrigation technology in the 64,000-acre Wellton-Mohawk Irrigation and Drainage District, east of Yuma, Arizona. And what those farmers learn, to satisfy the agreement, could be applicable to many other arid areas within the United States and worldwide, as water and energy demands increase.

77:05B-045
MASS BALANCE MONITORING OF LAND APPLICATION SITES FOR WASTEWATER RESIDUALS,
Smith, J.L., McWhorter, D.B., Trout, T.J.
Colorado State University, Department of Agricultural and Chemical Engineering, Fort Collins, Colorado 80523.
Transactions of the American Society of Agricultural Engineers, Vol. 20, No. 2, Paper No. 76-2065, p 309-312, March-April, 1977. 4 fig, 2 tab, 8 ref.

Descriptors: *Waste water disposal, *Sludge disposal, *Soils, Groundwater, Heavy metals, Leachates, Leaching, Groundwater movement, Soil amendments, Wastes, Sewage sludge, Water table, Water levels, On-site investigations, Soil contamination, Water pollution, Pollutants, Monitoring.

The soil can serve as a receiving medium and a final form of treatment by removing and decomposing various constituents in the sludge. Land application, when properly controlled, incorporates ultimate disposal with resource recovery. This paper proposed use of the mass balance concept for predicting groundwater quality and buildup of heavy metals in soils due to application of wastewater sludges. The concept is based on the principle of continuity of mass and an idealization of the flow system. Data from the Boulder, Colorado municipal sludge applications site were used to illustrate practical application of the concept. Mass balance reduces the lag time between application and measurement and uses measurement made prior to dilution of potential contaminants. A major deficiency in the concept is that, while it predicts a buildup of heavy metals in the soil, it does not indicate their availability to plants. However, other research has indicated that there is no cumulative effect of heavy metals and that plant uptake is not normally a problem in soils having near neutral pH.

77:05B-046
QUALITY ASPECTS OF AGRICULTURAL RUNOFF AND DRAINAGE,
The Task Committee on Agricultural Runoff and Drainage of the Water Quality Committee of the Irrigation and Drainage Division.
American Society of Civil Engineers, New York, New York.
Journal of the Irrigation and Drainage Division, Vol. 103, No. IR4, p 475-495, December 1977. 4 tab, 67 ref, 1 append.

Descriptors: Agriculture, Drainage, Eutrophication, Pesticides, Nutrients, Runoff, Sedimentation, Water management (Applied), Water pollution, Water quality.

In this report, the American Society of Civil Engineers Task Committee on Agricultural Runoff and Drainage has summarized the literature and research findings with respect to sources of pollutants, nature of downstream impacts, and relationships between pollutant loads and certain physical variables. Agricultural discharges from nonirrigated lands are significant contributors of nitrogen, phosphorus, and pesticides to downstream receiving waters. State-of-the-art knowledge indicates that management practices directed toward control of erosion, control of runoff, and management of fertilizer and pesticide application can reduce total pollutant load carried off-site from agricultural lands. The development of on-site discharge water quality control measures, as contemplated under Pl 92-500, must be predicated on detailed surveys of a more specific nature due to the high degree of variability in the factors influencing water-borne pollutant transport.

77:05B-047
DIMENSIONLESS SOLUTIONS OF BORDER-IRRIGATION ADVANCE,
Katopodes, N.D., and Strelkoff, T.
California University, Department of Land, Air and Water Resources, Water Science and Engineering Section, Davis, California.
Journal of the Irrigation and Drainage Division, Vol. 103, No. IR4, p 401-417, December 1977. 14 fig, 11 ref, 30 equ. 2 append.

Descriptors: Computers, Hydraulics, Hydrodynamics, Irrigation engineering, Mathematical models, Surface irrigation, Model studies.

The equations of border-irrigation flow are written in dimensionless form and solved numerically at three different levels of mathematical approximation. For the advance phase three independent parameters exist: the Froude number based on normal depth, the dimensionless exponent of the Kostiakov infiltration equation, and a dimensionless parameter determining the deviation of flow conditions from normal. It is shown both by order of magnitude analysis and from the results of the numerical computation that the inertia terms in the governing equations are unimportant for border flow (Froude number approximately zero). The model governed by the remaining two parameters, the zero-inertia model, is used to generate dimensionless advance trajectories and related information for all practical combinations of these two parameters. An additional advance trajectory is computed for each value of the dimensionless infiltration exponent using the normal-depth model to show the range of applicability of the latter.

77:05B-048
SOLUBLE AND SEDIMENT NITROGEN LOSSES AS RELATED TO LAND USE AND TYPE OF SOIL IN EASTERN CANADA,
Neilsen, G.H., and MacKenzie, A.F.
Macdonald College, Ste. Anne de Bellevue, Department of Renewable Resources, Quebec, Canada.
Journal of Environmental Quality, Vol. 6, No. 3, p 318-321, July-September, 1977. 2 fig, 4 tab, 25 ref.

Descriptors: *Agricultural runoff, *Nitrogen compounds, *Sediments, *Runoff, *Agricultural watersheds, Water quality, Leaching, Water pollution sources, Nitrates, Nutrients, Pollutants, Water analysis, Water chemistry, Nitrites, Nitrogen, Analytical techniques, Canada, Soil analysis.

In order to assess the amounts and types of nitrogen lost in agricultural drainage, seven agricultural watersheds, with a range of land use patterns and types of soil in southwestern Quebec and southeastern Ontario, were selected, and measurements of discharge rates, soluble inorganic nitrogen, and sediment Kjeldahl nitrogen were made during 1974-75. Correlations of the losses with land use and kind of soil were used to identify critical watershed factors affecting nitrogen loss. Soluble inorganic N concentrations in streams did not exceed 3.5 micrograms/ml. No watershed lost more than 5 kg/ha soluble N, except for the watershed with the maximum corn acreage (33%), which lost 22.8 kg N/ha per year. The pronounced significance of spring melt runoff was demonstrated by the movement of from 56 to 100% of annual soluble N from the monitored watersheds during March, April, and May. Sediment was a major transporter of N in the area, moving from 22 to 67% of total watershed N. Watersheds with greater corn acreage and relatively impermeable soils lost more soluble N, while watersheds with more organic soils and greater cultivated area lost more sediment N.

77:05B-049

QUALITY OF WATER DISCHARGED FROM THREE SMALL AGRONOMIC WATERSHEDS IN THE MAUMEE RIVER BASIN,
Jones, L.A., Smeck, N.E., and Wilding, L.P.
Ohio Agricultural Research and Development Center, Wooster, Ohio 44691.
Journal of Environmental Quality, Vol. 6, No. 3, p 296-302, July-September, 1977.
1 fig, 5 tab, 17 ref.

Descriptors: *Sediments, *Lake Erie, *Water pollution sources, *Water quality, *Agricultural runoff, *Soil analysis, Geology, Glacial drift, Analytical techniques, Sediment transport, Particle size, Water pollution, Calcium, Magnesium, Agricultural watersheds, Sodium, Potassium, Soil chemistry, Lakes, Ohio.

The investigation was aimed at evaluating the quality of water and the characteristics of sediments leaving three nearly level watersheds in the Lake Plain sector of the Maumee River Basin during a 32-month period as a function of soils comprising the watersheds. Each watershed consisted of a soil of major extent (Paulding, Hoytville, or Millgrove) developed from the three most extensive geologic deposits present in the basin: lacustrine, glacial till, and beach sand, respectively. The results indicated that water quality is a function of soil characteristics, discharge, and year. The fine-textured Paulding watershed yielded lower concentrations of calcium, magnesium, and bicarbonate ions than the other two watersheds, but higher concentrations of sodium, potassium, and phosphorus. High concentrations of the latter three elements were attributed to the presence of septic tank effluent in the drainage ditch samples. The Paulding watershed also yielded the highest concentration of sediment, which implies that nearly level watersheds of the basin, particularly fine-textured watersheds, may represent significant contributors of sediment entering the Maumee River. Flocculation of clay minerals in the sediments during fluvial transport resulted in increasing particle size and changing mineralogy on moving downstream from headwater areas.

77:05B-050

NITRATE-NITROGEN AND CHLORIDE MOVEMENT THROUGH UNDISTURBED FIELD SOIL,
Shuford, J.W., Fritton, D.D., and Baker, D.E.
Alabama A and M University, Normal, Alabama.
Journal of Environmental Quality, Vol. 6, No. 3, p 255-259, 1977. 1 fig, 7 tab, 10 ref.

Descriptors: *Soil water movement, *Dispersion, *On-site tests, *Pennsylvania, *Nitrogen, Soil water, Nitrates, Chlorides, Mixing, Percolation, On-site investigations, Movement, Irrigation, Analytical techniques, Analysis, Sampling, Ion transport, Ions.

Results were presented from a field study conducted to determine whether large pores represent a major pathway for NO3-N and Cl movement through undisturbed soil. A soil containing 410 ppm NO3-N and Cl as KNO3 and KCl was added to 3 experimental field plots enclosed by wooded barriers to prevent runoff. Initial and final soil samples were taken at various profile depths for ion analyses. Most of the NO3-N and Cl added in solution moved vertically with the water through the profile. Ion movement was influenced by large soil pores between structural units. A fourth field plot was designed to compare field-measured NO3-N and Cl concentrations with theoretical calculations, using time-dependent water flow velocity and dispersion equations. Soil solution samples were taken for ion analyses. Due to the incomplete mixing of water and ions with all soil pores, theoretical equations did not completely explain the field-measured NO3-N and Cl distribution.

77:05B-051
EFFECT OF SUSPENDED PARTICLES AND THEIR SIZES ON NITRIFICATION IN SURFACE WATER,
Kholdebarin, B., and Oertli, J.J.
Pahlavi University, Shiraz, Iran.
Journal Water Pollution Control Federation, Vol. 49, No. 7 p. 1693-1697, July 1977. 2 fig, 10 ref.

Descriptors: *Nitrification, *California, *Oxidation, *Surface waters, *Particle size, Ammonium compounds, Suspended particles.

Results of studies with water samples from the Whitewater River in Southern California clearly indicate the importance of the presence of suspended particulates and of particle size in nitrifying bacteria in surface water. While organisms can function well in media lacking measurable suspended solid materials, their activities will be enhanced as the amount of particulates increases in the solutions; the stimulating effect of particles is largely caused by their acting as a physical support for the proliferation of the nitrifying bacteria, rather than as base exchange sites for the substrates used in nitrification processes. Also, it appears particles as large or larger than the organism are most efficient in stimulating the nitrification process, contradicting findings of earlier studies which concludes that particles with diameters in excess of 0.7 microns are not essential for rapid biological nitrification in aquatic systems.

77:05B-052
A MODEL FOR THE TRANSPORT OF PESTICIDES IN SOIL WITH DIFFUSION-CONTROLLED RATES OF ADSORPTION AND DESORPTION,
Leistra, M.
Laboratory for Research on Insecticides, Marijkeweg 22, Wageningen, The Netherlands.
Agriculture and Environment, Vol. 3, No. 4, p 325-335, October 1977. 5 fig, 1 tab, 13 ref.

Descriptors: Adsorption, Model studies, Soils, Soil investigations, Rainfall, Simulation analysis, Pesticides.

The downward movement of a pesticide in soil, caused by different rainfall patterns, was simulated in a computation model. The movement occurred in the mobile region of a hypothetical soil system by convection together with hydrodynamic dispersion, and by diffusion. Lateral transport took place by diffusion into and out of a soil region with a stagnant liquid phase. With 40 mm of rainfall in 2 days, lateral diffusion distances of a few mm or more caused substantial deviation from the concentration--depth relationship for equilibrium adsorption. With 40 mm of rainfall scattered over 20 days, lateral diffusion distances up to a few mm had little effect, but those of about 10 mm or more had a very strong influence. The initial condition near the soil surface was extemely important. When the pesticide was initially present in the mobile region, overall mobility was comparatively great. Mobility was found to be much lower than with instantaneous adsorption and desorption, when the initial condition was equilibrium between the mobile and stagnant regions near the soil surface.

77:05B-053
A LABORATORY STUDY ON THE ROLE OF STREAM SEDIMENT IN NITROGEN LOSS FROM WATER,
Sain, P., Robinson, J.B., Stammers, W.N., Kaushik, N.K., and Whiteley, H.R.
National Research Council of Canada, Department of Environmental Biology, University of Guelph, Guelph, Ontario, Canada.
Journal of Environmental Quality, Vol. 6, No. 3, p 274-278, July-September, 1977. 4 fig, 4 tab, 14 ref.

Descriptors: Laboratory tests, Sediments, Sedimentation, Nitrogen, Nitrates, Denitrification, Temperature, Water quality, Streams.

Laboratory experiments were conducted on samples of sediment collected from a stream having an appreciable input of nitrate at its source. Earlier work had shown that the water lost much of the nitrate as it moved downstream, presumably by denitrification. Columns of sediment were reconstituted in plexiglass tubes, overlain with water containing nitrate, and incubated at 10, 15, or 22C. The water was aerated with a helium-oxygen mixture. Nitrate concentration decreased rapidly but the rate varied with temperature and depth of sediment. At 22C, in water overlying 10-cm columns of sediment, over 90% of the nitrate was removed in three weeks from a solution originally containing 10 mg/liter nitrate-N. Nitrate disappeared less rapidly at lower temperatures and when sediment columns were less than 5 cm deep. It was concluded that in columns less than 5 cm deep and at low temperatures nitrate diffused to the bottom of the columns, while columns 5 cm deep or more were effectively of infinite depth. Because of the interdependence of diffusion from the liquid phase into the sediment and denitrification, it is not possible to infer kinetics of denitrification in these experiments. It appeared that denitrification in these columns proceeded at a rate compatible with observations made previously in the stream from which the sediment originated.

77:05B-054
PARTITIONING AND TRANSPORT OF LEAD IN LAKE WASHINGTON,
Baier, R.W., and Healy, M.L.
Duke University, Department of Chemistry, Marine Laboratory, Beaufort, North Carolina 28516.
Journal of Environmental Quality, Vol. 6, No. 3, p 291-296, July-September, 1977. 9 fig, 3 tab, 13 ref.

Descriptors: Lead, Runoff, Sediments, Sedimentation, Model studies, Adsorption, Absorption, Limnology.

Input of lead to Lake Washington appears to result from the settling of airborne Pb onto surface waters and the washing of terrestrial accumulations to the lake as runoff. Some of the Pb received by the lake is associated with particles that sink, while the remainder leaves the lake with the overflow. The range in Pb concentration during two years of sampling was 0.04 to 6.6 ppb. The path of Pb to the sediments is not direct but involves cycling through both liquid and solid phases. Over 70% of the total Pb entering the lake is retained by sediment. Lead in top layers of sediment ranged from 242 ppm near a heavily used bridge to 4 ppm near the major tributary of the lake. A simple compartment model accounts for some of the interchanges between dissolved and particulate forms of Pb through the processes of adsorption, absorption, and complexation. The time required to achieve steady-state conditions for the model is comparable to the yearly flushing period. Large shifts in the annual timing of flushing and mixing are encountered because of meteorological changes.

77:05B-055
NITRATE DISTRIBUTION AND VARIABILITY IN IRRIGATED FIELDS OF NORTHEASTERN COLORADO,
Ludwick, A.E., Soltanpour, P.N., and Reuss, J.O.
Colorado State University, Department of Agronomy, Fort Collins, Colorado 80523.
Agronomy Journal, Vol. 6, No. 4, p 710-713, July-August, 1977. 1 fig, 6 tab, 16 ref.

Descriptors: Nitrates, Irrigation, Irrigation effects, Colorado, Fertilizers, Fertilization, Nitrogen, Nutrients, Soil profiles, Sampling.

Fertilizer N recommendations in the Great Plains and Western United States are commonly based on soil NO3- tests, although NO3- content within soil profiles is subject to rapid change. The purpose of this study was to evaluate NO3- distribution within diverse soil profiles and determine NO3- changes occurring over winter. Twenty-six irrigated farm fields were systematically sampled in 1974 and 1975 by dividing them into 61 x 61 m grids (0.37 ha) and sampling to a 120-cm depth by 30-cm increments. Eleven fields were resampled for fall versus spring comparisons. Nitrate content tended to be greatest in the surface 30-cm and decrease with depth; only three fields deviated markedly from the general pattern.

77:05B-056

UPTAKE BY BARLEY OF WATER TABLE-OR SURFACE-APPLIED CADMIUM,

Kirkham, M.B.
Oklahoma State University, Department of Agronomy, Stillwater, Oklahoma.
Soil Science Society of America Journal, Vol. 41, No. 6, p 1125-1129,
November-December, 1977. 3 fig, 3 tab, 19 ref.

Descriptors: *Cadmium, *Absorption, *Barley, Laboratory tests, Soil contamination, Plant physiology, Water pollution, Pollutants, Path of pollutants, Groundwater, Leaching, Leachate, Effluents, Drainage, Water table, Soil science, Cadmium uptake.

Solution of Cd were placed for 66 days at the bottom or top of columns (42-cm long by 15-cm diam) containing find sandy loam soil, half of which were planted with barley and half of which were bare, to determine rate of movement upward or downward of Cd. Three solutions with Cd, as CdSO4, were used: distilled water with 0.1 microgram/ml Cd; distilled water with 10 microgram/ml Cd; secondary effluent with 10 microgram/ml Cd. An average of 200 ml/day was added to the top or bottom of columns with plants; there was not drainage water with top additions. An average of 100 or 50 ml/day was added to the top or bottom, respectively, of columns without plants. Drainage water, which collected at the bottom of columns without plants and watered from the top, was analyzed daily for Cd. Plants and soil were analyzed weekly for Cd concentration. In less than seven days, Cd applied at the surface moved to the bottom and Cd applied at the bottom moved to the surface. At harvest, plants treated with Cd at the bottom contained up to three times more Cd than plants treated with Cd at the top because roots of plants with Cd at the bottom contained higher concentrations of Cd than roots of plants in columns with Cd at the top. Columns without roots had higher concentrations of extractable Cd than columns with roots. Concentrations of Cd in leachate from columns receiving 10 microgram Cd/ml effluent were about two times higher than concentrations of Cd in leachate from columns receiving 10 microgram Cd/ml water. The results showed that barley roots more readily absorbed Cd placed in a shallow water table than Cd placed in the soil surface.

SECTION XX

WATER QUALITY MANAGEMENT AND PROTECTION

EFFECTS OF POLLUTION (GROUP 05C)

77:05C-001
QUALITY OF WATER FOR IRRIGATION,
Ayers, R.S.
California University, Department of Water Science and Engineering, Davis, California.
Journal of the Irrigation and Drainage Division, American Society of Civil Engineers, Vol. 103, No. IR2, p 135-154, June 1977. 5 tab, 13 ref.

Descriptors: Water quality, Salinity, Irrigation, Irrigation effects, Crop production, Agriculture, Leaching, Electrical conductance.

Water quality means different things to different people. Quality usually denotes "suitability" for use and is difficult to evaluate except in terms related to its specific use. For irrigation, water suitability is related to its effect on soils and crops, and on the management that may be necessary to control or compensate for a water quality related problem.

77:05C-002
IRRIGATION WATER QUALITY EVALUATION,
Christiansen, J.E., Olsen, E.C., and Willardson, L.S.
Utah State University, Department of Agricultural and Irrigation Engineering, Logan, Utah.
Journal of the Irrigation and Drainage Division, American Society of Civil Engineers, Vol. 103, No. IR2, p 155-169, June 1977. 4 fig, 6 tab, 22 ref.

Descriptors: Water quality, Irrigation, Irrigation water, Salinity, Saline water, Electrical conductance, Crop production, Irrigation practices.

Irrigation water quality is very seldom adequately defined. The term is sometimes used to mean only the salinity expressed as total dissolved solids, TDS, in milligrams per liter or the equivalent, parts per million. The TDS is determined by evaporating a given volume of water and weighing the residue. Most often the salinity is determined by measuring the electrical conductivity, EC (or specific conductance as it sometimes is called), and reporting it in millimhos per centimeter at 25 degrees C or in micromhos per centimeter. Such determinations of irrigation water quality are useful but are too limited in scope to be completely satisfactory for making dependable decisions on the usefulness of a particular water for irrigation.

77:05C-003
THE PHOSPHORUS STATUS OF EUTROPHIC LAKE SEDIMENTS AS RELATED TO CHANGES IN LIMNOLOGICAL CONDITIONS--PHOSPHORUS MINERAL COMPONENTS,
Wildung, R.E., Schmidt, R.L., and Routson, R.C.
Battelle, Pacific Northwest Laboratory, Richland, Washington 99352.
Journal of Environmental Quality, Vol. 6, No. 1, p 100-104, January-March, 1977. 1 fig, 3 tab, 21 ref.

Descriptors: Phosphorus, Limnology, Sediments, Sedimentation, Eutrophication, Water quality.

Studies of the relationship between limnological factors and changes in the P status of noncalcareous sediments of a eutrophic lake previously indicated that changes in sediment inorganic P were directly related to the biological productivity of the surface waters. This relationship was particularly pronounced in a shallow bay where sediment P decreased with lake phytoplankton growth and increased with their decline. The present studies were undertaken to identify the inorganic P components responsible for these changes using chemical techniques for characterization of P in sediments where changes occurred.

77:05C-004
STERILITY IN RICE CULTIVARS AS INFLUENCED BY MSMA RATE AND WATER MANAGEMENT,
Wells, B.R., and Gilmour, J.T.
University of Arkansas, Department of Agronomy, Fayetteville, Arkansas 72701.
Agronomy Journal, Vol. 69, No. 3, p 451-454, May-June, 1977. 3 tab, 16 ref.

Descriptors: Rice, Crop production, Arkansas, Cotton, Soils, Soil investigations, Soil water, Saturated soils.

In recent years an expansion of rice acreage in Arkansas has resulted in rice being produced on soils with a history of cotton production. Most of these cotton soils have had repeated applications of monosodium methanearsonate (MSMA) as a herbicide. There is some evidence that arsenical residues in the soil can lead to sterility in rice. In an effort to answer this question, a field experiment was conducted on a Crowley silt loam soil in 1975 to evaluate the influence of MSMA on plant growth and yield of rice.

77:05C-005
EFFECTS OF IRRIGATION METHODS ON GROUNDWATER POLLUTION BY NITRATES AND OTHER SOLUTES,
Wendt, C.W., Onken, A.B., Wilke, O.C., and Lacewell, R.D.
Texas Agricultural Experiment Station, Route 3, Lubbock, Texas 79401.
Publication No. EPA-600/2-76-291, December 1976. 330 p, 197 fig, 46 tab, 23 ref.

Descriptors: Irrigation, Fertilizers, Nitrogen, Isotopes, Water pollution, Soil water.

Sprinkler irrigation, furrow irrigation, subirrigation, automated subirrigation, criteria for applying irrigation water, methods of applying fertilizer and sources of fertilizer were investigated as to their potential to decrease possible pollution from nitrate and other solutes in a loamy fine sand soil overlying a shallow aquifer in Knox County, Texas. Less nitrate-nitrogen was available for leaching in subirrigation systems than furrow and sprinkler systems. Less irrigation water was applied with automated subirrigation systems than with the other irrigation systems. However, crop water requirement was not significantly changed--the soil water was more efficiently used. Fertilizer remained in the root zone if the water applied was based on potential evapotranspiration and leaf area regardless of the irrigation system or the criteria used to apply the irrigation water. Banded fertilizers moved differently in the different irrigation systems. Subirrigation has the possibility of having irrigation return flow with lower concentrations of other solutes than sprinkler or furrow systems. Banding fertilizer in the bed was superior to banding below the level of the water, furrow and applications in the irrigation water relative to quality of irrigation return flow. No other source of nitrogen fertilizer was indicated to be superior. Current fertilization practices are not causing major increases in the nitrate-nitrogen level in the aquifer.

SECTION XXI

WATER QUALITY MANAGEMENT AND PROTECTION

WASTE TREATMENT PROCESSES (GROUP 05D)

77:05D-001
RECYCLING AGRICULTURAL RUNOFF,
Walker, P.N., and Lembke, W.D.
Illinois University, Department of Agricultural Engineering, Urbana-Champaign, Illinois.
Available from the National Technical Information Service, Springfield, Virginia, 22161 as PB-264 578, Illinois Water Resources Center, Urbana, Illinois, Research Report No. 119, January 1977, 88 p. 11 fig, 6 tab, 72 ref.

Descriptors: *Irrigation, *Water reuse, *Impervious soils, *Illinois, *Recycling, *Agricultural runoff, Farm ponds, Computer models, Clays, Crop production, Drainage, Costs, Economics.

The recycling agricultural runoff concept is the storage of excess water from agricultural land and using this water for irrigation of the same land when moisture supplies are low. Coincidentally, the system also recycles pesticides and nutrients, keeping them out of other parts of the environment. The claypan soils of Illinois appear to be best suited for water recycling when surface storage is used. Sandy soils are best suited to interstitial water storage. A review and analysis of literature on irrigation, drainage, reservoirs, pesticides, and nutrients, as it pertains to a recycling system is presented. Nutrient and pesticide recycling result in negligible cost or benefits to agricultural crops. There was insufficient information to determine the economic benefit to the environment of this recycling. A model was developed relating irrigation and drainage to crop yield using intermediate variables of soil moisture and air temperature. The model predicted that an acre-ft. of storage would be required per acre of irrigated watershed. The model was not successful at predicting the increase in yield resulting from irrigation and/or drainage. An example economic analysis reveals that under present conditions recycling agricultural runoff is not economically justifiable as a general practice in the claypan region of Illinois.

77:05D-002
FACTORS AFFECTING NITRIFICATION,
Hockenbury, M.R., Daigger, G.T., and Grady, C.P.L., Jr.
Engineering-Science, Incorporated, Atlantic, Georgia.
Journal of the Environmental Engineering Division-ASCE, Vol. 103, No. EE1, p 9-19, February 1977. 1 fig, 3 tab, 13 ref.

Descriptors: *Nitrification, *Bacteria, *Organic matter, *Activated sludge, Domestic wastes, Industrial wastes, Dissolved oxygen, Growth rates, Aeration, Hydrogen ion concentration, Waste water treatment.

Laboratory studies were conducted to investigate factors which affect nitrification. These included the effect of heterotrophic bacteria and organic compounds on nitrifying bacteria, and the possible adverse effects created by material released in waste water during treatment in a plug flow activated sludge aeration basin. Results indicated no effects by actively metabolizing heterotrophic bacteria upon nitrate production by autotrophic nitrifiers. Domestic sewage did not affect nitrate production by nitrifying bacteria when inhibitory industrial wastes were absent. No adverse effects from treatment in plug flow activated sludge aeration basins were found when suitable pH and dissolved oxygen levels were maintained for autotrophic nitrifiers. Heterotrophic bacteria released growth factors which slightly stimulated autotrophic nitrifer activity. Many inhibitory compounds in tested sewage were apparently degraded within the first half-hour of activated sludge treatment.

77:05D-003
GOAL PROGRAMMING MODEL FOR WATER QUALITY PLANNING,
Bishop, A.B., Narayanan, R., Grenney, W.J., and Pugner, P.E.
Utah State University, Department of Civil and Environmental Engineering,
Logan, Utah.
Journal of the Environmental Engineering Division, Proceedings of the American
Society of Civil Engineers, Vol. 103, No. EE2, Proceedings Paper No. 12883,
p 293-306, April 1977. 4 fig, 7 tab, 9 ref.

Descriptors: *Waste water treatment, *Water quality control, *Multiple purpose, *River basins, *Planning, Management, Optimization, Streams, Standards, Regions, Costs, Mathematical models, Equations, Systems analysis.

The broad goals of the Federal Water Pollution Control Act Amendments (PL 92-500) and the regional nature of water quality plans require that multiple objectives be considered in planning. Goal programming is an extension of linear or integer programming where the objective is to minimize the deviations from a set of goals, subject to systems constraints. A goal programming model is applied to an example river basin system where the planning goals are the quality levels of four constituents required or three desired beneficial water uses in five stream reaches, and the budget availability in four municipal regions for financing wastewater treatment. The model solution indicates the combination of treatment levels and costs that minimizes deviations from user quality and budgetary goals for all stream reaches. Values of deviation variables in the solution indicate the water quality levels achieved. A comparison with the minimum cost solution for meeting stream standards identifies the costs and tradeoffs of achieving higher user quality goals.

77:05D-004
PHOSPHATE REMOVAL BY SANDS AND SOILS,
Tofflemire, T.J., and Chen, M.
New York State Department of Environmental Conservation, Research Unit, Albany, New York.
Ground Water, Vol. 15, No. 5, p 377-387, September-October, 1977. 6 fig, 13 tab, 31 ref.

Descriptors: *Unsaturated flow, *Laboratory tests, *Waste water disposal, *Recharge, *Phosphates, Filtration, Soil characteristics, Infiltration, Soil profiles, Soils, Sands, Waste disposal, Water quality, Filters, Soil filters, Adsorption, Analytical techniques.

Phosphate retention by soils is especially important for tile fields and rapid infiltration systems near lakes where eutrophication is a problem. The use and application of the phosphate adsorption isotherm test is estimate a soil's phosphate removal ability was discussed. It was found that in New York State, the till soils had a greater phosphate retention ability than the outwashes, the more acid soils had a greater phosphate retention than the more basic or calcareous soils. The B horizon of many of the soils had a high phosphate capacity. However, this is often neglected in rapid infiltration systems because the waste water is discharged below the B horizon. The phosphate removal in column studies and field studies in rapid infiltration systems was found to be greater than predicted by the rapid isotherm test. Instermitten sand filters with 2 ft sand and underdrains were found to have a limited ability to remove phosphate. A substantial portion of slowly fixed phosphate is non-leachable by rain water. Methods to predict and design for phosphate retention by sands and soils were described.

77:05D-005
ATTENUATION OF WASTE WATER ELUTRIATED THROUGH GLACIAL OUTWASH,
Fetter, C.W., Jr.
Wisconsin University, Department of Geology, Oshkosh, Wisconsin.
Ground Water, Vol. 15, No. 5, p 365-371, September-October, 1977. 3 fig, 3 tab, 20 ref.

Descriptors: *Waste water treatment, *Tertiary treatment, *Laboratory tests, *Glacial drift, Soil filters, Adsorption, Surfaces, Heavy metals, Ion exchange, Recharge, Cadmium, Lead, Ammonia, Nitrification, Phosphorus.

Secondarily treated waste water was added to plastic columns filled with calcareous glacial outwash soil for a period of 10 weeks. More than 99% of the phosphorus was retained in the upper 50 cm of the soil, primarily due to adsorption. Ammonia, nitrite, and organic nitrogen were nitrified biologically to nitrate nitrogen. There was no measurable mercury in the column effluent, and it was present in only 2 samples of the waste water. About 30% of the cadmium was removed by ion exchange in the soil columns. Lead was not removed, probably due to the prior exhaustion of the lead exchange sites.

77:05D-006
PHOSPHATE REMOVAL USING WASTE CALCIUM SULFATE,
Theis, T.L., and Fromm, G.A.
Notre Dame University, Department of Civil Engineering, Notre Dame, Indiana.
Journal of the Environmental Engineering Division, Vol. 103, No. 335, p 951-955, 4 fig, 8 ref, 1 append.

Descriptors: Phosphates, Calcium, Water pollution, Water quality, Water quality control, Waste water, Waste water treatment.

Calcium sulfate (gypsum) is a common and inexpensive mineral which is among the cheapest sources of soluble calcium ion available. Relatively pure calcium sulfate is produced as a byproduct in several industries including chemical, pharmaceutical (2), and, in the near future, it will also be produced by high sulfur coal-fired utilities which must remove stack gas SO2. Thus, on a local basis it may be obtained at a markedly reduced cost, transportation being a major cost factor. This study was undertaken to explore the possibility of employing gypsum as a supplemental chemical for the removal of phosphate from wastewaters, and to determine under what conditions it can be utilized in this manner.

77:05D-007
SALT REMOVAL EFFICIENCIES ON LAND DISPOSAL OF SWINE WASTE,
Grier, H.E., Gupta, G.C., and Tiwari, S.C.
Alcorn State University, Department of Animal Science, Lorman, Mississippi.
Journal of the Environmental Engineering Division, Vol. 103, No. EE4, p 551-556, August 1977. 2 fig, 1 tab, 11 ref, 1 append.

Descriptors: Ammonia, Nitrates, Nutrients, Suspended solids, Waste disposal, Waste water treatment, Effluents.

Swine waste aerobic lagoon effluent was sprinkled overland and the runoff water was collected. Both the waste effluent and the runoff water were analyzed for nitrate, ammonia, chloride, suspended solids, BOD, and specific conductance. Removal efficiency of nitrate dropped from 62% to 32% on prolonged disposal of swine waste effluent, in six months. Data for suspended solids and specific conductance support these results for nitrate removal efficiency. Removal efficiencies for ammonia and chloride were higher and showed a very small decrease with time. BOD removal efficiency was 95% throughout the six-month period of the study. The system showed signs of "overloading" for nitrate removal but not for BOD removal.

77:05D-008
NITROGEN TRANSFORMATIONS IN LAND TREATMENT,
DiGiano, F.A., and Su, Y-S.
Massachusetts University, Department of Civil Engineering, Amherst, Massachusetts.
Journal of the Environmental Engineering Division, Vol. 103, No. EE6, p 1075-1087, December 1977. 4 fig, 1 tab, 21 ref, 21 equ, 2 append.

Descriptors: Algae, Biological treatment, Lagoons, Land reclamation, Model studies, Nitrogen, Sewage treatment, Waste disposal, Water pollution.

The storage lagoon of a land treatment system functions as a dynamic biological reactor in which algae and bacteria can transform input nitrogen. A quantitative estimate of these nitrogen transformations is needed for proper design of the spray irrigation component of land treatment. In this study, a simulation model was developed to predict the concentrations of inorganic and organic nitrogen and algae in the lagoon throughout the winter storage and irrigation months; pilot plant data were used for verification. Both the predicted and observed results indicated a large reduction in inorganic nitrogen caused by algal uptake during most of the irrigation period. The model was then applied to achieve a better balance between nitrogen supplied by the lagoon and crop demand throughout the growing season.

77:05D-009
GROUND WATER POLLUTIONS. PART 2. POLLUTION FROM IRRIGATION AND FERTILIZATION, CITATIONS FROM THE NATIONAL TECHNICAL INFORMATION SERVICE DATA BASE,
Lehmann, E.I.
National Technical Information Service, 5285 Port Royal Road, Springfield, Virginia 22161.
National Technical Information Service, United States Department of Commerce, NTIS/PS-76-0750, NTIS/PS-75/740, and NTIS/PS-75/072, February 1977, p 1-240.

Descriptors: Groundwater, Pollutants, Fertilization, Irrigation effects, Waste water (pollution), Solid wastes, Nitrates, Phosphates, Abatement, Water pollution, Irrigation, Water conservation.

This bibliography contains abstracts of Federally-funded research covering all aspects of groundwater pollution from irrigation and fertilization. The reports include topics dealing with the pollution from sewage and waste water irrigation, land spreading of sludges and solid wastes, nitrate and phosphate accumulation in soils, pollution control and abatement planning, salt build-up from irrigation, the use of tile drains in groundwater pollution control, and groundwater recharge studies. (This updated bibliography contains 240 abstracts, 18 of which are new entries to the previous edition.)

SECTION XXII

WATER QUALITY MANAGEMENT AND PROTECTION

ULTIMATE DISPOSAL OF WASTES (GROUP 05E)

77:05E-001
STORAGE OF TREATED SEWAGE EFFLUENT AND STORM WATER IN A SALINE AQUIFER, PINELLAS PENINSULA, FLORIDA.
Rosensheim, J.S., and Hickey, J.J.
Geological Survey, Water Resources Division, Tampa, Florida.
Ground Water, Vol. 15, No. 4, p 284-293, July-August, 1977. 5 fig, 3 tab, 11 ref.

Descriptors: *Waste disposal, *Injection wells, *Waste water disposal, *Underground storage, *Effluents, Saline water, Aquifers, Test wells, Aquifer characteristics, Water quality control.

The Pinellas Peninsula, an area of 750 square kilometers (290 square miles) in coastal west-central Florida, is a small hydrogeologic replica of Florida. Most of the Peninsula's water supply is imported from well fields as much as 65 kilometers (40 miles) inland. Stresses on the hydrologic environment of the Peninsula and on adjacent water bodies resulting from intensive water-resources development and waste discharge, have resulted in marked interest in subsurface storage of waste water (treated effluent and untreated storm water) and in future retrieval of the stored water for nonpotable use. If subsurface storage is approved by regulatory agencies, as much as 70 million gallons a day of waste water could be stored underground within a few years, and more than 150 million gallons a day could be stored in about 25 years. This storage would constitute a large resource of nearly freshwater in the saline aquifers underlying about 520 square kilometers (200 square miles) of the Peninsula.

77:05E-002
SERVO CONTROLLED OPTIMIZATION OF NITRIFICATION-DENITRIFICATION OF WASTE WATER IN SOIL,
Enfield, C.G.
Robert S. Kerr Environmental Research Lab, Ada, Oklahoma.
Journal of Environmental Quality, Vol. 6, No. 4, p 456-458, October-December, 1977.
5 fig, 1 tab, 9 ref.

Descriptors: *Infiltration, *Nitrification, *Denitrification, *Sewage treatment, *Municipal wastes, Chemical reactions, Sludge, Soil amendments, Treatment facilities, Electrical properties, Waste water disposal, Waste water treatment.

Studies were conducted to develop a servo control system which adjusts the rate of waste water application to land to ensure nitrification-denitrification. Operation of the control system is based on the potentials of five platinum electrodes used in conjunction with a Calomel reference electrode. A servo controller was used to regulate application of municipal trickling filter final effluent to four gravelly loam soil columns. The controller adjusted the frequency of waste water application with respect to the Pt electrode potential 6 cm under the soil surface. The duration of each application was regulated according to a target potential measured 30 cm beneath the surface, optimizing denitrification. Three soil columns received 7.5 metric tons (carbon) of digested municipal sludge/ha in the upper 30 cm of the profile. Waste water application was continuously allowed by the servo controller for the column that contained no sludge. Essentially all total Kjeldahl nitrogen-nitrogen was converted to nitrate-nitrogen in the upper 3 cm of this column. About 45% of the dissolved nitrogen disappeared in this column. Addition of sludge increased apparent dentrification, so that total nitrogen removal exceeded 90%.

SECTION XXVII

WATER QUALITY MANAGEMENT AND PROTECTION

WATER QUALITY CONTROL (GROUP 05G)

77:05G-001
EFFECT OF LEACHING FRACTION ON RIVER SALINITY,
Suarez, D.L., and Rhoades, J.D.
Agricultural Research Service, Salinity Laboratory, Riverside, California.
Journal of the Irrigation and Drainage Division, American Society of Civil
Engineers, Vol. 103, No. IR2, Proceedings Paper 13017, p 245-257, June 1977.
7 tab, 9 ref, 2 append.

Descriptors: *Drainage water, *Leaching, *Irrigation engineering, *Salinity, Management, Soil chemical properties, Calcium carbonate, Porosity, Rivers, Water quality, Return flow, Drainage, Root zone, Saline soils, Gypsum, Model studies.

The effects of 0.10 and 0.40 irrigation leaching fraction management on amount of salt precipitated in the soil and river channel and compositions of drainage and river water were calculated for each of the three river types routed through nine successive hypothetical irrigated valleys. The calculations assume dissolution of $CaCO_3$ (in the soil) and return of irrigation drainage waters. Rivers undersaturated with $CaCO_3$ were slightly less saline under low versus high leaching. Rivers saturated with $CaCO_3$ were unaffected by irrigation management. Rivers saturated with $CaCO_3$ and approaching saturation with gypsum experienced substantial reductions in salinity under low leaching compared to high leaching. For $CaCO_3$-saturated rivers, a change from high to low leaching results in a rootzone soil porosity reduction of 0.008% more per year. For rivers that result in the precipitation of gypsum, soil porosity was reduced about 0.08% more per year for low as compared to high leaching.

77:05G-002
REDUCTION OF 2, 4-D LOAD IN SURFACE RUNOFF DOWN A GRASSED WATERWAY,
Asmussen, L.E., White, A.W., Jr., Hauser, E.W., and Sheridan, J.M.
Agricultural Research Service, Southern Region, Tifton, Georgia.
Journal of Environmental Quality, Vol. 6, No. 2, p 159-162, April-June, 1977.
4 fig, 3 tab, 8 ref.

Descriptors: *Herbicides, *Grassed waterways, *Water pollution, *Agricultural chemicals, *Watershed management, Pesticides, Weed control, Surface drainage, Agricultural watersheds, Surface runoff, Coastal plains, Pesticide removal, Pollutants, Sediments, Surface runoff, Watersheds (basins).

The effectiveness of a grassed waterway in decreasing 2, 4-D ((2,4-dichlorophenoxy) acetic acid)) content in surface runoff was investigated. Corn plots were treated with 2, 4-D (0.56 kg/ha) and runoff produced by applying simulated rain was directed through a 24.4-m-long grassed waterway. The 2, 4-D concentrations were measured under wet and dry antecedent waterway and plot conditions. Reduction in 2, 4-D load in waterways results from water loss by infiltration, sediment loss, and by attachment-absorption on vegetative and organic matter. Of the simulated rainfall applied 1 day after application of 2, 4-D, 50% of the water ran off the plots under dry antecedent soil conditions, and 78% ran off under wet conditions. Infiltration reduced runoff flowing down the waterway an additional 25% under dry conditions and 2% under wet conditions. Suspended sediment reduction in the waterway was 98 and 94% of the total amount moving from the plot for the dry and wet waterway conditions, respectively. The total loss (on sediment and in solution) of the applied 2,4-D from the plot in the dry and wet states was 2.5 and 10.3%, respectively.

77:05G-003

WATER ALLOCATION AND PRICING FOR CONTROL OF IRRIGATION-RELATED SALINITY IN A RIVER BASIN,

Scherer, C.R.
California University, Department of Engineering Systems, Los Angeles, California.
Water Resources Research, Vol. 13, No. 2, p 225-238, April 1977. 10 fig, 5 tab, 49 ref.

Descriptors: *Water allocation (policy), *Water quality control, *Salinity, *Irrigation, *Dynamic programming, *Economic efficiency, Optimization, Water districts, Water rights, Pricing, Control, River basins, Downstream, Agriculture, Decision making, Operations research, Legal aspects, Hydraulics, Equations, Water yield.

The optimal allocation of water to sequential irrigators is considered with emphasis on downstream salinity damages caused by salt-concentrating mechanisms inherent in irrigated agriculture. Outlined is a physical hydrosalinity model that characterizes multi-irrigation district rivers and is used to develop a dynamic programming framework for the efficient allocation of water among districts. The focus is upon returns (maximization of net benefits) to farmers as a function of quantity and quality of water diverted and upon developing an operational model on which a viable water rights pricing scheme could be based. The allocation is achieved using the dynamic programming framework with decision variables of amount diverted, land irrigated, and amount of irrigation canals lined. This framework is used to investigate a scheme whereby water is purchased and held for downstream use solely as a dilutant. The basis is established in principle for an operational water rights market where all purchasers are financed by downstream beneficiaries. This framework would facilitate discovery of reallocations that are Pareto superior to existing allocations and computation of the individual purchase offer that must be made to each district to compensate it for acreage withdrawn from irrigation under these new allocations in order to reduce salinity impact on the downstream users. Four example solutions are presented. Probably, better resolution of salinity management problems will evolve if trade-offs and "efficiency frontiers" are correctly perceived.

77:05G-004

EFFECTS OF INCREASED FERTILIZER RATES ON NITROGEN CONTENT OF RUNOFF AND PERCOLATE FROM MONOLITH LYSIMETERS,

Chichester, F.W.
Agricultural Research Service, Temple, Texas.
Journal of Environmental Quality, Vol. 6, No. 2, p 211-217, April-June, 1977, 4 fig, 6 tab, 9 ref.

Descriptors: *Nitrogen compounds, *Fertilizers, *Nitrates, *Leaching, *Agricultural chemicals, Water quality, Nutrients, Pollutants, Water chemistry, Nitrogen, Water pollution sources, Percolation, Runoff, Hydrology, Soil chemistry, Agricultural runoff, Fertilization.

Nitrogen (N) fertilizer was applied to meadow and corn cropped lysimeters at rates up to 322 and 672 kg/ha per year, respectively, to determine the effects on chemical quality of surface water. Runoff and percolate samples collected from May 1971 through April 1975 were analyzed for inorganic and total N content. Results were evaluated from crop and soil cover treatment differences and were compared with data from a similar, earlier study on the same lysimeters in which very low rates of N fertilizer were used. Nitrogen losses in runoff were greatest in the summer when intense rainfall events occurred shortly after the date of fertilizer application. Nitrogen loss by leaching was greatest during the winter when percolation rates increased because of low evapotranspirational demand. Results of the study demonstrated that improved fertilizer management, involving application rates in balance with crop nutrient requirements, soil incorporation of fertilizer materials, and adequate soil cover, will minimize runoff and leaching losses which reduce fertilizer efficiency and adversely affect water quality.

77:05G-005

NITROGEN AND WATER MANAGEMENT TO MINIMIZE RETURN-FLOW POLLUTION FROM POTATO FIELDS OF THE COLUMBIA BASIN,

McNeal, B.L., Carlile, B.L., and Kunkel, R.
Washington State University, Department of Agronomy and Soils, Pullman, Washington.
Proceedings of National Conference on Irrigation Return Flow Quality Management, Colorado State University, Fort Collins, Colorado, p 33-43, May 16-19, 1977.
7 tab, 7 ref.

Descriptors: Nitrogen, Fertilizers, Fertilization, Return flow, Water management (applied), Potatoes, Columbia River, Crop production, Irrigation, Sprinkler irrigation, Furrow irrigation.

Cooperative field studies have evaluated levels of dissolved soil N, and corresponding crop yields for selected potato production practices in the Columbia Basin area of Washington. High dissolved-N levels were found throughout the growing season in well-managed potato fields. Such levels were decreased by decreased fertilization rate, use of slow-release N fertilizers, or sprinkler-application of N fertilizers. Careful water management during sprinkler irrigation proved capable of maintaining dissolved-N within the root zone of subsequent crops by season's end, even on very sandy sites. Alternate-furrow irrigation also proved effective in "trapping" much banded fertilizer N within the plant root zone on heavier-textured furrow-irrigated soils. Periodic recovery of residual N by other crops in the rotation is necessary to prevent eventual return flow contamination, however. Site-to-site sampling variability necessitated the use of composited soil samples, rather than fixed-position soil solution extraction cups, for adequate monitoring of dissolved-N levels in soils of the area. Neither dissolved soil N nor plant petiole NO3-N proved to be reliable predictors of crop N needs at the high residual soil N levels commonly found in recropped potato fields of the Columbia Basin.

77:05G-006

MODELING SALINITY OF IRRIGATION RETURN FLOW WHERE SOURCES AND SINKS ARE PRESENT,

Hanks, R.J., Willardson, L.S., and Melamed, D.
Utah State University, College of Agriculture, Department of Soil Science and Biometeorology, Logan Utah.
Proceedings of National Conference on Irrigation Return Flow Quality Management, Colorado State University, Fort Collins, Colorado, p 99-107, May 16-19, 1977.
10 fig, 2 tab, 9 ref, 4 equ.

Descriptors: Model studies, Simulation analysis.

Managing irrigation return flow when salinity sources and sinks are present presents many complex difficulties. Models developed to include the source sink term in an empirical way show that wide variations in irrigation quality and quantity will have little influence on return flow for many years where the source-sink term is important. The quantity of salt in return flow is primarily determined by water flow because the soil solution concentration changes very slowly. Where a water table is present, successful irrigation might be practiced with no return flow for some conditions. Even where no source-sink term is considered, model predictions indicate irrigation management with no return flow for several years is possible with little reduction in yield. The influence of irrigation system uniformity is shown to be significant over several years time. Thus, it is evident that many possibilities for return flow management exist but the long term effects should not be overlooked.

77:05G-007

COMBINING AGRICULTURAL IMPROVEMENTS AND DESALTING OF RETURN FLOWS TO OPTIMIZE LOCAL SALINITY CONTROL POLICIES,

Walker, W.R.
Colorado State University, Department of Agricultural and Chemical Engineering, Fort Collins, Colorado.
Proceedings of National Conference on Irrigation Return Flow Quality Management, Colorado State University, Fort Collins, Colorado, p 203-213, May 16-19, 1977.
7 fig, 9 ref, 22 equ.

Descriptors: Model studies, Mathematical simulation, Desalination, Irrigation, Colorado, Seepage.

Mathematical simulations of the cost-effectiveness relationship for various agricultural and desalination alternatives for controlling salinity in irrigation return flows are being developed. The question of respective feasibility for each type of control is determined through minimizing the total costs, thereby optimally selecting the best measures to implement. To demonstrate the concept, desalting and canal linings were compared for the Grand Valley in western Colorado. Results indicate that desalting exhibits superior feasibility to linings of canals where seepage rates are low. In general, desalting will exhibit its best feasibility when applied to large-scale applications and when salt pickup rates stemming from irrigation return flows are small.

77:05G-008
PRACTICAL APPLICATIONS OF IRRIGATION RETURN FLOW QUALITY MODELS TO LARGE ACREAGES,
Shaffer, M.J., and Ribbens, R.W.
United States Bureau of Reclamation, Engineering and Research Center, Denver, Colorado.
Proceedings of National Conference on Irrigation Return Flow Quality Management, Colorado State University, Fort Collins, Colorado, p 217-223, May 16-19, 1977.
6 fig, 1 tab, 12 ref.

Descriptors: Model studies, Simulation analysis, Water quality, Water quality control, Irrigation, Return flow.

Numerous return flow quality simulation models have been developed in recent years. Practical use of these tools on large irrigation projects is discussed in terms of study objectives, data requirements and availability, model detail and sensitivity, inherent limitations, and reliability and interpretation of results. The modeling efforts of the Bureau of Reclamation and other institutions are used to illustrate the utility and practicability of these new tools. Potential and present model users should gain valuable insight into the benefits and pitfalls of return flow quality modeling.

77:05G-009
MODELING THE IRRIGATION RETURN FLOW SYSTEM--CURRENT CAPABILITIES AND FUTURE NEEDS,
Walker, W.R.
Colorado State University, Department of Agricultural and Chemical Engineering, Fort Collins, Colorado 80523.
Proceedings of National Conference on Irrigation Return Flow Quality Management, Colorado State University, Fort Collins, Colorado, p 261-265, May 16-19, 1977.

Descriptors: Model studies, Simulation analysis, Water quality, Mathematical studies.

A large number of mathematical models have been developed and tested for simulation of irrigation return flow systems. The strengths and weaknesses of the technology have been examined as part of two recent studies by the author. This paper discusses what seems to be some of the more critical problems in using these models, the relative strengths of those existing, and important research and development needs for maximizing their utilization in the future.

77:05G-010
HOW THE NPDES PROGRAM WILL DEFINE PRESENT WATER QUALITY CONDITIONS,
Merrill, G.
Central Valley Regional Water Quality Control Board, Sacramento, California.
Proceedings of National Conference on Irrigation Return Flow Quality Management, Colorado State University, Fort Collins, Colorado, p 289-291, May 16-19, 1977.
3 tab.

Descriptors: Surface irrigation, Return flow, California, Suspended solids, Irrigation, Water quality control.

Monitoring of surface irrigation supplies and surface return flows is being carried on through the NPDES permit program under Public Law 92-500. This program encompasses approximately 1.3 million acres of land in the San Joaquin Valley of California alone. The EC and suspended solids of the irrigation returns frequently exceed basin water quality control plan objectives (standards) adopted in 1971 by the Central Valley Board for the receiving water.

77:05G-011
THE SULPHUR CREEK PILOT PROJECT: A PRACTICAL APPROACH TO CONTROL OF POLLUTANTS LEAVING IRRIGATED FARMLANDS,
Spencer, J., Horton, M., and Gleaton, J.
State of Washington, Department of Ecology, Olympia, Washington.
Proceedings of National Conference on Irrigation Return Flow Quality Management, Colorado State University, Fort Collins, Colorado, p 307-319, May 16-19, 1977.
2 fig, 1 tab.

Descriptors: Washington, Return flow, Water quality, Fertilizers, Pesticides, Crop production, Irrigation, Economics.

The Sulphur Creek project grew out of the momentum and confusion resulting from attempts to apply a National Pollution Discharge Elimination System (NPDES) permit to irrigation return flows. The result has been a project containing what appeared to be compatible and, for the most part, admirable objectives--soil and water conservation, improved water quality, improved fertilizers and pesticides application, improved crop production, and local control. Along with education and technical assistance for the individual farmer, this unique program is structured to provide local control to decisions affecting the farmer. The Best Management Practices concept assumes that informed decisions and improved management will generally provide improved crop production, conservation of soil resources, and cleaner water. The project is currently just over one year old. Details of the technical success of the project will not be available for some time. Unlike most types of industry covered by the NPDES permits, irrigation return flow improvement represents complex hurdles which have to be overcome by facing the realities of technology, politics, economics, and social patterns.

77:05G-012
THE "208" PLANNING EFFORT FOR IRRIGATED AGRICULTURE IN THE STATE OF WASHINGTON,
Horton, M., and Spencer, J.
State of Washington, Department of Ecology, Olympia, Washington.
Proceedings of National Conference on Irrigation Return Flow Quality Management, Colorado State University, Fort Collins, Colorado, p 321-323, May 16-19, 1977.
1 fig.

Descriptors: Irrigation, Irrigation effects, Washington, Agriculture, Water quality, Economics.

The Department of Ecology is responsible for developing a "208" Plan for irrigated agriculture in the State of Washington. It is anticipated that Best Management Practices (BMP) will be utilized by individuals to come into compliance with a state-wide regulatory program (possibly NPDES). Water quality committees formed through local conservation districts, with representatives from all interested groups, will develop BMP based on the following criteria: (1) economic feasibility; (2) local acceptability; and (3) water quality improvement.

77:05G-013
EVALUATING APPROPRIATE TECHNOLOGIES FOR SALINITY CONTROL IN GRAND VALLEY,
Evans, R.G., Walker, W.R., Smith, S.W., and Skogerboe, G.V.
Colorado State University, Department of Agriculture and Chemical Engineering, Fort Collins, Colorado 80523.
Proceedings of National Conference on Irrigation Return Flow Quality Management, Colorado State University, Fort Collins, Colorado, p 375-384, May 16-19, 1977.
3 fig, 2 tab, 3 ref.

Descriptors: Technology, Irrigation practices, Irrigation systems, Canal linings, Colorado, Colorado River, Salinity, Irrigation, Economics.

A summary of the results of applied research on salinity control of irrigation return flows in the Grand Valley of Colorado is presented for the period of 1969 to 1976. Salinity and economic impacts are described for the Grand Valley Salinity Control Demonstration Area which contains approximately 1600 hectares and involves most of the local irrigation entities in the valley. During the eight years of the demonstration project, 12.2 km of canals were lined, 26.54 km of laterals were lined, 16.4 km of drainage tile was installed, a wide variety of on-farm improvements were constructed, and an irrigation scheduling program was implemented. The total value of the constructed improvements in the demonstration area was almost $750,000.

77:05G-014
DEVELOPMENT OF BEST MANAGEMENT PRACTICES FOR SALINITY CONTROL IN GRAND VALLEY,
Walker, W.R., Skogerboe, G.V., and Evans, R.G.
Colorado State University, Department of Agriculture and Chemical Engineering,
Fort Collins, Colorado 80523.
Proceedings of National Conference on Irrigation Return Flow Quality Management,
Colorado State University, Fort Collins, Colorado, p 385-393, May 16-19, 1977.
5 fig, 7 ref, 16 equ.

Descriptors: Canal linings, Water quality, Water quality control, Desalination, Colorado River, Salinity, Colorado.

Cost-effectiveness functions for various on-farm, conveyance, and desalting salinity control alternatives were developed for the Grand Valley of western Colorado. These functions were then optimized to determine the best management practices on a valley-wide scale. The results indicate the relative importance of lateral linings and on-farm improvements over either canal lining or desalting. Generalized curves are presented for application of this analysis to other similar areas where less information is available.

77:05G-015
WATER QUALITY: AN OVERVIEW,
Mostertman, L.J.
Technische Hogeschool, International Course in Hydraulics and Sanitary Engineering,
Delft, The Netherlands.
Agro-Ecosystems, Vol. 3, No. 3, p 239-251, June 1977. 8 ref.

Descriptors: Water resources, Pollution, Water pollution, Water chemistry, Nutrients, Salinity, Thermal pollution, Water resources.

The water resources of the world are described in relation to: (a) evaluation of present and future needs, (b) collection of data, (c) biological pollution, (d) drinking water supply, (e) pollution by chemicals, (f) pollution by excessive nutrients, (g) salinity and alkalinity, (h) thermal pollution, (i) organic waste treatment and disposal, and (j) need for a systems approach. The possibilities of constructive action, particularly on an international front, are discussed.

77:05G-016
REDUCING WATER QUALITY DEGRADATION THROUGH MINIMIZED LEACHING MANAGEMENT,
Rhoades, D.L., and Suarez, D.L.
United States Department of Agriculture, Agricultural Research Service, United
States Salinity Laboratory, Post Office Box 672, Riverside, California 92502.
Agricultural Water Management, Vol. 1, No. 2, p 127-142, September 1977. 10 tab,
15 ref, 3 equ.

Descriptors: Water quality, Water quality control, Leaching, Water resources, Salinity, Saline soils, Agriculture.

The U.S.A. has adopted a policy of enhancing water quality and of conserving natural resources. The concept of minimized leaching has been advanced to help meet these goals by reducing salinity pollution from irrigated agriculture. It has received considerable attention by those concerned with management of water resources and is promoted by some as a generally applicable method for minimizing salinity pollution. This paper reviews the basis of the concept and identifies the conditions under which minimized leaching will and will not enhance water quality.

77:05G-017
DISPOSAL OF SALT WATER DURING WELL CONSTRUCTION, PROBLEMS AND SOLUTIONS,
Pitt, W.A.J., Jr., Meyer, F.W., and Hull, J.E.
Geological Survey, Water Resources Division, Miami, Florida.
Ground Water, Vol. 15, No. 4, p 276-283, July-August, 1977. 6 fig, 1 tab.

Descriptors: *Injection wells, *Drilling, *Water pollution sources, *Saline water, *Florida, Aquifers, Drilling fluids, Sewage disposal, Monitoring, Pumping, Groundwater.

Recent interest in disposal of treated sewage effluent by deep-well injection into saline aquifers has increased the need for proper disposal of salt water as more wells are drilled annually. Three cases of contamination of an unconfined aquifer in Florida by salt water spilled or discharged from wells trapping the underlying saline aquifer are examined in this study. In two cases, near Miami, contamination resulted from disposal of salt water into unlined surface bits during injection well construction. At the third site near West Palm Beach, minor contamination was caused by accidental spills during construction. Precautions taken at the latter site included the use of a brine injection well for disposal of saline water and a closed circulation drilling system to minimize spillage. A concurrent monitoring program facilitated early detection of salt spill effects, thus, mapping of the contaminant and restoration efforts were effective and relatively inexpensive. Suggestions for further increasing the safety of drilling into saline aquifers include the construction of impermeable drilling pads with gutters and employing special procedures for handling drilling muds.

77:05G-018
REGIONAL MANAGEMENT OF URBAN AND AGRICULTURAL POLLUTION,
Lashkari, R.S., Hwang, C.L.. and Fan, L.T.
Windsor University, Ontario, Canada.
Journal of the Water Pollution Control Federation, Vol. 49, No. 8, p 1877-1888, August 1977. 6 fig, 6 tab, 13 ref.

Descriptors: *Water quality control, *Salinity, *Biochemical oxygen demand, *Economic efficiency, *Water policy, *Optimization, *Drainage area, Costs, Constraints, Water demand, Agriculture, Utah, Standards, Desalination plants, Irrigation, Equations, Mathematical models, Systems analysis.

Presented is an approach to water quality management in areas where a variety of urban and agricultural pollutants are discharged into a body of water. The Utah Lake drainage area is considered in which the urban and agricultural return flow from four districts of the Utah Valley are discharged into the Lake. A model of salinity and biochemical oxygen control is used which coordinates the pollution control activities of the urban and agricultural sectors in each district. The model consists of a wastewater treatment system and a desalting plant in the urban sector, and a combination of structural and practice improvements in the irrigation system of the agricultural sector. The objective is to minimize the costs of maintaining certain biochemical oxygen demand and salt reduction standards in the districts' aggregate effluents to the Lake under two assumptions: that each district is to maintain the standards independently, and that the salinity-biochemical oxygen demand control efforts of the individual districts are regionally coordinated. The results indicate that savings can be achieved through regional coordination of pollution control efforts.

77:05G-019
DETAILED RETURN FLOW SALINITY AND NUTRIENT SIMULATION MODEL,
Shaffer, M.J.
Bureau of Reclamation, Denver, Colorado.
Proceedings of the International Salinity Conference, Texas Tech University, Lubbock, Texas, August 16-20, 1976, p 127-141. 8 fig, 18 ref,

Descriptors: *Simulation analysis, *Nutrients, *Return flow, *Salinity, Model studies, Drainage, Nitrogen, Water quality, Lysimeters, Irrigation effects.

A computer model allows the simultaneous consideration of many complex chemical and physical processes in the unsaturated and saturated zones. The model simulates one-dimensional unsaturated flow and two-dimensional saturated flow (to tile drains), as well as chemical reactions and transport processes involving the major cations and anions, and nitrogenous species. The program also includes crop uptake of water and nutrients. A numerical integration technique is utilized to solve the appropriate differential equations, and generate transient predictions throughout the soil-aquifer system, and at the drains. Utilization of a master site technique allows application of the model to predict irrigation return flow quality and quantity from large irrigated areas involving thousands of acres. Verification has been accomplished on large acreages as well as field plots, lysimeters, and laboratory columns. The model has a well-documented user's manual and has been applied to several large irrigation projects.

77:05G-020
NATIONAL WATER QUALITY GOALS AND IRRIGATED AGRICULTURE,
Johnston, W.R.
Westlands Water District, Fresno, California.
Journal of the Irrigation and Drainage Division, America Society of Civil Engineers, Vol. 103, No. IR2, p 109-114, June 1977. 10 ref.

Descriptors: Irrigation, Water quality, Water, Return flow, Irrigation effects, Agriculture, Irrigation water, Crop production.

In 1972, the United States government, reflecting the concern of people everywhere over the pollution of this country's water resources, passed the Federal Water Pollution Control Act Amendments of 1972. This law created certain national water quality goals and has had great impact on municipal and industrial activities that relate to the water systems of the United States.

77:05G-021
PL 92-500 V. POLLUTION BY IRRIGATION RETURN FLOW,
Blackman, W.C., Jr., Wills, C.G., and Celnicker, A.C.
National Enforcement Investigations Center, Denver, Colorado.
Journal of the Irrigation and Drainage Division, Proceedings of ASCE, Vol. 103, No. 2, p 207-220, June 1977. 3 fig, 14 ref.

Descriptors: *Federal Water Pollution Control Act, *Federal Reclamation Law, *Irrigation districts, *Irrigation return flow, Irrigation practices, Pollution abatement, Water pollution control, Irrigation, Permits, Regulation, Administrative agencies, Governmental interrelations, Effluent limitation.

This paper summarizes the problems of applying the municipal/industrial waste treatment oriented permit approach of the National Pollutant Discharge Elimination System to the control of irrigation return flow as embodied in the Federal Water Pollution Control Act Amendments of 1972. It is held that there must be acceptance and implementation of optimum application of irrigation water, even though optimum application may involve use of less than the prior appropriated water right. In the promulgation of regulations by the Environmental Protection Agency, the EPA should recognize that regional and delegated state administrators must have flexibility to designate permittees on the basis of logic. Since the Bureau of Reclamation plans, administers and operates many newly established irrigation projects, it is uniquely qualified to provide leadership and guidance toward optimum practices within project areas. In established irrigation districts and major irrigated areas, EPA should initiate a program of grants and contracts to enable optimum operation of plots representative of each area. Such recommendations and others will require modified viewpoints of irrigators, legislators, regulatory agencies and others.

77:05G-022
PROCEEDINGS OF NATIONAL CONFERENCE: IRRIGATION RETURN FLOW QUALITY MANAGEMENT,
Law, J.P., and Skogerboe, G.V.
Conference sponsored by the Environmental Protection Agency and Colorado State University.
Proceedings of National Conference on Irrigation Return Flow Quality Management, Colorado State University, Fort Collins, Colorado, p 1-451, May 16-19, 1977, 193 fig, 136 tab, 310 ref, 106 equ, 1 append.

Descriptors: Irrigation, Irrigation systems, Irrigation practices, Crop production, Crop response, Return flow, Water quality control, Model studies, Agriculture, Technology, Salinity, Fertilization, Groundwater, Runoff, Erosion, Sedimentation, Water resources, Water conservation, Irrigation efficiency, Water law, Water management (applied), Pollutants, Pollution abatement, Pollutant identification.

The results of numerous research projects and investigations are presented which focus upon defining appropriate technologies for alleviating water quality problems from irrigated agriculture; most of these technologies involve improved water management practices. In addition, case studies are presented for key irrigated areas in the United States which provide necessary insights and experiences as to how technologies might be most effectively implemented. The primary objectives of the conference were: (1) to present the results of the irrigation return flow research and development program of the United States Environmental Protection Agency; (2) to interpret the research results into an interdisciplinary approach for solving problems of irrigation return flow quality management; and (3) to provide a forum for presenting and discussing the alternatives for implementing irrigation return flow quality control.

77:05G-023

CONTROL OF NONPOINT WATER POLLUTION FROM AGRICULTURE: SOME CONCEPTS,
Frere, M.H., Woolhiser, D.A., Caro, J.H., Stewart, B.A., and Wischmeier, W.H.
Agricultural Research Service, Southern Great Plains Watershed Research Center, Chickasha, Oklahoma.
Journal of Soil and Water Conservation, Vol. 32, No. 6, November-December, 1977, p 260-264. 6 fig, 1 tab, 13 ref.

Descriptors: *Water pollution control, *Erosion, *Fertilizers, *Pesticides, *Farm management, *Nonpoint source pollution, Federal water pollution control act, Agricultural chemicals, Watersheds, River basins, Runoff, Farm wastes, Nutrients, Pollution taxes, Education, Conservation, Alternative practices, Incentives.

Federal and State laws require that methods be developed for evaluating nonpoint pollution problems and for recommending control practices. Since the major responsibility for control lies with organizations covering large areas, such as river basins or states, the task is difficult at best. Control methods can be classified into two groups: (1) methods applicable to large areas, and (2) farming practices that are site-specific because of climate, topography, economics, etc. Some advantages and disadvantages of education, incentives, taxation, and legal penalties for broad areas are discussed. The use of flow charts for erosion, nutrient, and pesticide problems are briefly discussed. The charts should be useful in selecting farming practices that reduce nonpoint pollution and in evaluating their consequences.

77:05G-024

TILLAGE SYSTEM EFFECTS ON RUNOFF WATER QUALITY: PESTICIDES,
Baker, J.L., and Johnson, H.P.
Iowa State University, Department of Agricultural Engineering, Ames, Iowa 50011.
Presented at the 1977 Winter Meeting, American Society of Agricultural Engineers, December 13-16, 1977, Palmer House, Chicago, Illinois, p 1-14. 2 fig, 4 tab, 17 ref.

Descriptors: Pesticides, Runoff, Sedimentation, Corn, Erosion, Soil erosion, Sediments, Water quality.

Pesticide runoff losses in sediment and water were measured for six small watersheds planted to continuous corn by three tillage systems: conventional, till-plant, and ridge-plant. Decreased runoff and erosion for the till-plant and ridge-plant systems resulted in decreased pesticide losses; however, pesticide concentrations in sediment and/or water were sometimes higher (relative to conventional).

77:05G-025

AN INTRODUCTION TO FOUR OVERVIEWS: ARID AND SEMI-ARID LANDS; SOIL LOSS; TROPICAL FORESTS AND WOODLANDS; WATER QUALITY,
Tolba, M.K.
The United Nations Environment Program.
Agro-Ecosystems, Vol. 3, No. 3, p 183-184, June 1977.

Descriptors: Erosion, Water quality, Water, Watersheds (basins), Climates, Arid lands, Arid climates.

One of the major tasks assigned by the United Nations General Assembly to the Governing Council of the United Nations Environment Program, in the aftermath of recommendations made at the United Nations Conference on the Human Environment convened at Stockholm in 1972, was to "keep under review the world environmental situation in order to ensure that emerging environmental problems of wide international significance receive appropriate and adequate consideration." To assist in carrying out this task, the Executive Director was requested by the Governing Council of UNEP, at its second session in 1974, to prepare each year reviews of one or more of the priority subject areas of the Environment Program, in addition to preparing an annual State of the Environment Report which summarizes the most important and the major emerging issues that affected the environment during the preceding year.

77:05G-026
THE CONTROL OF NITRATE AS A WATER POLLUTANT,
Swoboda, A.R.
Texas A and M University, Texas Agricultural Experiment Station, College Station, Texas 77843.
Publication No. EPA-600/2-77-158, August 1977. 141 p, 16 fig, 55 tab, 14 ref, 3 append.

Descriptors: Nitrates, Leaching, Soils, Crop production, Fertilizers, Fertilization, Nutrients, Lysimeters.

This study was based on the premise that the most logical approach to reducing nitrate leaching in soils was to limit the amount of nitrate in the soil solution at any one time. Methods of limiting the concentration of nitrate in the soil solution while maintaining an adequate supply of available nitrogen for plant growth are reported. Timing of nitrogen application was found to be a very effective means of reducing nitrate leaching. When nitrogen was applied in the fall, as much as 3-fold more nitrate was found to have leached below 60 cm in the soil by June as compared to applications made in March. A nitrification inhibitor, N-Serve, was found to be very effective in reducing the amount of nitrate leached. Slow release sulfur coated ureas and treatment of nitrogen fertilizers with N-Serve were found to be effective means of reducing leaching losses of nitrate when fertilizers were applied in the fall or winter.

77:05G-027
PREDICTION OF MINERAL QUALITY OF IRRIGATION RETURN FLOW: VOLUME I. SUMMARY REPORT AND VERIFICATION,
Bureau of Reclamation, Engineering and Research Center, Denver, Colorado 80225.
Publication No. EPA-600/2-77-179a, August 1977. 59 p, 5 fig, 2 tab, 6 ref.

Descriptors: Water quality, Return flow, Irrigation, Irrigation effects, Model studies, Salinity, Dissolved solids, Simulation analysis, Groundwater, Hydrology.

This volume of the report outlines the purpose and scope of the return flow research and specifically explains the capabilities of the conjunctive use model for predicting the mineral quality of irrigation return flow. The purpose of the research was to develop a conjunctive use model which would (1) predict the salinity contribution from new irrigation projects and (2) predict the change in return flow salinity that would result from operational changes on exisiting projects. The model developed and described herein describes the chemical quality in terms of eight ionic constituents and total dissolved solids. A nodal concept has been used to facilitate subdividing the project area along physical or hydrologic boundaries as desired. The study may be limited to 1 or as many as 20 nodes.

77:05G-028
PREDICTION OF MINERAL QUALITY OF IRRIGATION RETURN FLOW: VOLUME II. VERNAL FIELD STUDY,
Bureau of Reclamation, Engineering and Research Center, Denver, Colorado 80225.
Publication No. EPA-600/2-77-179b, August 1977. 106 p, 45 fig, 9 tab, 1 append.

Descriptors: Utah, Groundwater, Water quality, Irrigation, Irrigation water, Return flow, Crop production, Soil chemistry, Simulation analysis.

This volume of the report details the field investigations conducted to develop and validate the "Simulation Model of Conjunctive Use and Water Quality for a River System or Basin" as given in Volume III of this report. The studies were conducted in Ashley Valley, near Vernal, Utah. The investigations included: the quantity and quality of groundwater, irrigation water, and return flows; crop inventory and consumptive use; soil chemistry; and hydrological units to define nodes.

77:05G-029
PREDICTION OF MINERAL QUALITY OF IRRIGATION RETURN FLOW: VOLUME III. SIMULATION MODEL OF CONJUNCTIVE USE AND WATER QUALITY FOR A RIVER SYSTEM OR BASIN,
Bureau of Reclamation, Engineering and Research Center, Denver, Colorado 80225.
Publication No. EPA-600/2-77-179c, August 1977. 285 p, 43 fig, 18 tab, 1 append.

Descriptors: Computer programs, Simulation analysis, Model studies, Irrigation, Irrigation effects, Return flow, Water quality.

This volume of the report documents the development of a digital computer coded simulation model to predict the effect of irrigation of agricultural lands on the resulting irrigation return flow quality. The model is capable of simulating conjunctive uses of water, however, validation for this purpose was not performed. The model developed in this volume is much less rigorous than that presented in Volume V, however, it can be used to provide an assessment of water quality trends due to irrigation at much less cost than the detailed model. A user's manual is included in the report.

77:05G-030
PREDICTION OF MINERAL QUALITY OF IRRIGATION RETURN FLOW: VOLUME IV. DATA ANALYSIS UTILITY PROGRAMS,
Bureau of Reclamation, Engineering and Research Center, Denver, Colorado 80225.
Publication No. EPA-600/2-77-179d, August 1977. 222 p, 1 ref.

Descriptors: Return flow, Irrigation, Irrigation effects, Water quality, Computer programs, Model studies, Simulation analysis.

This volume of the report contains a description of the data analysis subroutines developed to support the modeling effort described in Volume III. The subroutines were used to evaluate and condition data used in the conjunctive use model. The subroutines include (1) regression analysis, (2) Gaussian probability function, (3) Beta distribution, and (4) Pearson's incomplete gamma function. For each of these subroutines, a brief theory is given plus a program listing and sample problem.

77:05G-031
CALLAHAN RESERVOIR: I. SEDIMENT AND NUTRIENT TRAP EFFICIENCY,
Rausch, D.L., and Schreiber, J.D.
Agricultural Research Service, North Central Watershed Research Center, Columbia, Missouri.
Transactions of the American Society of Agricultural Engineers, Vol. 20, No. 2, p 281-284, 290, March-April, 1977. 2 fig, 3 tab, 10 ref.

Descriptors: *Reservoirs, *Sediments, *Nutrients, *Missouri, *Trap efficiency, Sedimentation, Water pollution, Phosphorus, Nitrogen, Runoff, Inflow, Discharge (water), Path of pollutants, Lakes.

Small reservoirs remove and trap significant amounts of sediment and nutrients from storm runoff. Callahan Reservoir, a small flood-detention reservoir in central Missouri, which permanently stores 1 cm of runoff from its 1,440-ha drainage area, trapped an average of 87% of the incoming sediment, 72% of the total phosphorus (P), and 30% of the inorganic nitrogen (N) in 1973. Sediment efficiency and P trap efficiency in the reservoir were both related to the incoming sediment particle-size; however, only sediment trap efficiency was related to detention time. The annual amount of NO3 trapped seemed related to annual runoff volume. For 1973, the soluble nutrients, total soluble P, and NO3 were trapped at similar rates, 32% and 34%, respectively. More NH4, dissolved organic P and dissolved hydrolyzable P were found in outflow than in inflow. The increases, which are less than 2% of the nutrient budget, may be attributed to biological activity in the reservoir.

77:05G-032
CALLAHAN RESERVOIR: II. INFLOW AND OUTFLOW SUSPENDED SEDIMENT PHOSPHORUS RELATIONSHIPS,
Schreiber, J.D., Rausch, D.L., and McDowell, L.L.

United States Department of Agriculture Sedimentation Laboratory, Agricultural Research Service, Oxford, Mississippi.
Transactions of the American Society of Agricultural Engineers, Special Edition, Vol. 20SW, p 285-289, April 20, 1977. 5 fig, 4 tab, 23 ref, 1 equ.

Descriptors: Missouri, Sediments, Flood control, Reservoirs, Downstream, Agricultural watersheds, Phosphorus.

The inflow and outflow of Callahan Reservoir, located in an agricultural area near Columbia, Missouri, was studied for 1 year to understand the sediment and solution phosphorus (P) relationships. The solution phase was analyzed for dissolved organic, hydrolyzable, and ortho-P and the sediment was analyzed for total, inorganic, and organic P. The discharge weighted mean solution phase concentration of dissolved organic, hydrolyzable, and ortho-P for the inflow was 0.008, 0.002 and 0.059, mg/l, respectively, as compared with 0.011, 0.005, and 0.021 mg/l for the outflow. The outflow sediment had a larger concentration (mu g/g) of total, inorganic, and organic P than did the inflow sediment. However, because of sediment deposition within the reservoir, there was a 4-fold decrease in outflow suspended sediment P volume concentrations (mg/l). Isotopic dilution techniques with 32P were used to estimate the portion of sediment-P31 in equilibrium with solution-P31. The quantities of isotopically exchangeable sediment-P31 in the inflow and outflow sediments were 30 and 41 mu g/g, respectively.

77:05G-033
CALLAHAN RESERVOIR: III. BOTTOM SEDIMENT-WATER-PHOSPHORUS RELATIONSHIPS,
Olness, A., and Rausch, D.
Agricultural Research Service, Water Quality Management Laboratory, Durant, Oklahoma.

Transactions of the American Society of Agricultural Engineers, Vol. 20, No. 2, p 291-297, 300, March-April, 1977. 6 fig, 3 tab, 38 ref.

Descriptors: *Reservoirs, *Bottom sediments, *Water quality, Sediments, Chemical properties, Chemical analysis, Physical properties, Cores, Sampling, Phosphorus, Nutrients, Water chemistry, Lakes, Limnology.

Sediment core samples obtained from a 164,000 cu m reservoir in central Missouri showed highly significant correlations between sediment clay content and phosphorus concentrations. Both sediment clay content and phosphorus concentrations increased with distance from the reservoir inlet. No strong correlations between phosphorus concentration and sediment depth were observed. Phosphorus concentrations varied widely between and within core profiles ranging from less than 100 ppm to more than 1000 ppm and from less than 200 ppb to more than 3000 ppb for total phosphorus and total soluble phosphorus, respectively. The mean total phosphorus concentration in the reservoir water was 108 ppb. About 25% and 10% of the total suspended phosphorus was soluble phosphorus and soluble reactive phosphorus, respectively. The reservoir sediments seemed to serve as a phosphorus sink either through chemical adsorption or planktonic and mineral sedimentation.

77:05G-034
SOIL-SALT INTERACTIONS IN RELATION TO SALT CONTROL,
Biggar, J.W., and Tanji, K.K.
Land, Air and Water Resources Department, University of California, Davis, California.
Transactions of the American Society of Agricultural Engineers, Special Edition, Vol. 20SW, p 68-75, February 20, 1977. 1 tab, 50 ref, 9 equ.

Descriptors: Root zones, Return flow, Salts, Cation exchange, Ion exchange, Water management (applied), Crop production, Salt tolerance, Soils.

An appraisal is made on the difficulties of predicting and evaluating mass emission of salts in irrigation return flows. The more important physicochemical processes that occur in the root zone are identified and the complexity and state-of-the-art knowledge of them is discussed.

77:05G-035
RECLAIMING PARTIALLY CLOGGED TRICKLE EMITTERS,
Nakayama, F.S., Bucks, D.A., and French, O.F.
United States Water Conservation Laboratory, Agricultural Research Service, United States Department of Agriculture, Phoenix, Arizona.
Transactions of the American Society of Agricultural Engineers, Special Edition, Vol. 20SW, p 278-280, April 20, 1977. 1 fig, 1 tab, 9 ref.

Descriptors: Irrigation systems, Trickle filters, Clogging, Flow rate, Laboratory tests, Injection.

A trickle emitter system, which had become partially clogged after two years of operation even with extensive water filtration, was reclaimed successfully by treating the entire system with concentrated hypochlorite and acid solutions. Chemical cost per emitter was less than replacement cost for the emitter and supply tubing. Maintenance treatment with low levels of hypochlorite and acid prevented recurrence of emitter plugging.

77:05G-036
SOIL-ASPHALT MIXTURE FOR CANAL SEEPAGE CONTROL: LABORATORY STUDY,
Sommerfeldt, T.G.
Research Station, Agriculture Canada, Lethbridge, Alberta, TIJ 4B1, Canada.
Canadian Agricultural Engineering, Vol. 19, No. 2, p 111-115, December 1977.

Descriptors: Laboratory tests, Seepage control, Seepage, Asphalt, Soils, Irrigation canals, Model studies, Salinity, Linings.

A material for lining irrigation canals composed of soil, anionic asphalt emulsion, Wyoming bentonite, an enzymatic wetting agent, and water was developed in the laboratory. Discs of the material were tested for seepage control, and resistance to erosion, weathering, freezing, and thawing. A ditch model was subjected to a continuous stream of water for 30 days. The material was satisfactory under laboratory conditions. It had some flexibility and, when wet, was soft and spongy, similar to gum rubber. This flexibility would be advantageous for canals where shifting of the base or frost-heaving is a problem. But, because of its softness, damage from livestock and similar traffic may be a problem.

77:05G-037
WATER QUALITY CAN AFFECT MANAGEMENT PLANNING,
Ross, R.
Irrigation Age Magazine.
Irrigation Age, Vol. 12, No. 1, p 60,63, September 1977. 1 fig.

Descriptors: Sodium, Salts, Saline water, Soils, Irrigation, Irrigation effects, Irrigation practices, Water quality.

What if water is carrying a heavy load of sodium or other salts? Over a period of time, particularly on a fine-textured soil, a high concentration of sodium could change the character of the soil so that water could no longer penetrate it. A large amount of total salts could cause an "artificial drouth." High sodium and/or too much total salts are among the primary reasons that irrigation water which may appear to be fine may, in fact, be of poor quality. And once water quality becomes bad, you have what one expert we visited called a "serious question with very few good answers."

77:05G-038
ANNOTATED BIBLIOGRAPHY FOR WATER QUALITY MANAGEMENT,
United States Environmental Protection Agency, Water Planning Division, 401 M Street, S.W., Washington, D.C. 20460.
Annotated Bibliography for Water Quality Management, Fourth Edition, May 1977, p 1-59.

Descriptors: Water quality, Water quality control, Pollutant identification, Agriculture, Hydrology, Groundwater, Water pollution, Pollution, Model studies.

This bibliography has been prepared to assist those who are engaged in 208 water quality management. References cited have been selected for their applicability to water quality management and for their availability. A table of contents arranging the 226 references has been included. Each reference is followed by a short abstract and, whenever possible, by price and ordering information. Instructions for using the Government Printing Office, the National Technical Information Service, and for ordering books through the EPA Regional offices or the EPA Water Quality Management Information Center in Washington, D.C., are included.

77:05G-039
WATER AND ENERGY CONSERVATION THROUGH EFFICIENT IRRIGATION MANAGEMENT,
Stone, L.R.
Kansas State University, Kansas Water Resources Research Institute, Manhattan, Kansas.
Water Resources Research Conducted at Kansas State University and University of Kansas, Project Completion Report, PB 273 810, August 1977. 15 p, 2 fig, 7 tab, 7 ref.

Descriptors: Corn, Grain sorghum, Water use, Use rate, Grain yield, Irrigation, Soil profiles.

In a 3-year study, corn (Zea mays L.) and grain sorghum (Sorghum bicolor (L) Moench) yield and water use efficiency was evaluated as influenced by irrigation timing. The study was located at Tribune (mean annual rainfall of 17.0 inches) and Manhattan, (mean annual rainfall of 33.5 inches) Kansas. Treatments consisted of no in-season irrigation, a single in-season irrigation at one of three different growth stages, and irrigating at each of the three selected growth stages. Selected growth stages in corn were pre-tassel, silk emergence, and blister; in grain sorghum they were boot, half-bloom, and soft-dough. Each irrigation was 4 inches at Manhattan and 6 inches at Tribune. All Tribune plots received a preplant irrigation in April of each year. Water was applied to basin plots using gated pipe. With no in-season irrigation, the 3-year mean grain sorghum yields were greater than corn yields at both Manhattan and Tribune. The largest 3-year mean yield for corn receiving a single in-season irrigation was obtained with the irrigation during silk emergence at both Manhattan and Tribune. Grain sorghum yields from the single in-season irrigation treatments were similar and presented no single time that tended to be superior during the three study years. Corn responded well to the three in-season irrigations. The grain sorghum yield increase for plots receiving three in-season irrigation as opposed to those receiving only one in-season irrigation is insufficient to justify the two additional irrigations.

77:05G-040
CONTROL OF WATER POLLUTION FROM CROPLAND: VOLUME II. AN OVERVIEW,
Stewart, B.A., Woolhiser, D.A., Wischmeir, W.H., and Caro, J.H.
Agricultural Research Service, United States Department of Agriculture, Washington, D.C. 20250.
Publication No. EPA-600/2-75-026, June 1976. 187 p, 20 fig, 12 tab, 28 ref.

Descriptors: Runoff, Pesticides, Nutrients, Nonpoint source pollution, Hydrology, Sediment control, Erosion.

Engineering and agronomic techniques to control sediment, nutrient, and pesticide losses from cropland are identified, described, and evaluated. Methodology is developed to enable a user to identify the potential sources of pollutants, select a list of appropriate demonstrated controls, and perform economic analyses for final selection of controls. The basic principles on which control of specific pollutants is founded are reviewed, supplementary information is provided, and some of the documentation used in Volume I is presented. Volume I (Report No. EPA-600/2-75-026a) is available from NTIS as report no. PB 249-517.

77:05G-041
CONTROL OF SEDIMENTS, NUTRIENTS, AND ADSORBED BIOCIDES IN SURFACE IRRIGATION RETURN FLOWS,
Carter, D.L., and Bondurant, J.A.
United States Department of Agriculture, Agricultural Research Service, Western Region, Snake River Conservation Research Center, Kimberly, Idaho 83341.
Publication No. EPA-600/2-76-237, October 1976. 45 p, 2 fig, 7 tab, 49 ref.
(See 77:04A-042)

SECTION XXVIII

WATER RESOURCES AND PLANNING

TECHNIQUES OF PLANNING (GROUP 06A)

77:06A-001
A PROCESS FOR IDENTIFYING, EVALUATING AND IMPLEMENTING SOLUTIONS FOR IRRIGATION RETURN FLOW PROBLEMS,
Vlachos, E., Barrett, J.W.H., Huszar, P., Layton, J.J., and Radosevich, G.E.
Colorado State University, Department of Sociology, Fort Collins, Colorado 80523.
Proceedings of National Conference on Irrigation Return Flow Quality Management, Colorado State University, Fort Collins, Colorado, p 435-445, May 16-19, 1977.
1 fig, 1 tab.

Descriptors: Technology, Water quality, Water quality control, Return flow, Pollution, Economics.

The purpose of this study has been to develop an effective process for implementing technical and institutional solutions to the problem of return flow pollution. The process developed is to: (1) define the problem in terms of its legal, physical, economic and social parameters, (2) identify potential solutions in relation to the parameters of the problem, (3) test the implementability of these potential solutions for diverse situations, and (4) specify those solutions or groups of solutions which are the most effective in reducing pollution and are implementable. This process is initially conceptualized in the paper and then the general results of its application to three study areas in the western United States are summarized.

77:06A-002
SEASONAL AND STOCHASTIC FACTORS IN WATER PLANNING,
Bishop, A.B., and Narayanan, R.
Utah State University, Utah Water Research Laboratory, Logan, Utah.
Journal of the Hydraulics Division, American Society of Civil Engineers, Vol. 103, No. HY10, p 1159-1172, October 1977. 3 fig, 9 tab, 12 ref.

Descriptors: Water, Water quality, Irrigation, Model studies, Waste water, Waste water treatment.

Three contrasting formulations of a water allocation model were developed for this study; linear versus nonlinear costs, annual versus seasonal timeframe, and deterministic versus stochastic water supplies. In general, more information as to optimal planning configurations was obtained using the more realistic nonlinear, seasonal-stochastic model. The seasonal model gives better indication of facility sizing needed for wastewater treatment and results in overall lower costs than the annual model does. This is particularly important in the summer season when large volumes of secondary treated effluent are used for irrigation. Because of the stochastic variability of surface water more dependable, but more expensive, water sources are indicated in the optimal solution, resulting in higher costs.

77:06A-003
INNOVATIVE MANAGEMENT CONCEPT FOR 208 PLANNING,
Bulkley, J.W., and Gross, T.A.
Michigan University, Department of Civil Engineering and Natural Resources, Ann Arbor, Michigan.
Journal of the Water Resources Planning and Management Division, American Society of Civil Engineers, Vol. 103, No. WR2, p 227-240, November 1977. 4 fig, 16 ref.

Descriptors: Agriculture, Return flow, Water quality, Water quality control, Water pollution, Water pollution control.

Area-wide (Section 208) water quality planning is an ongoing activity in 176 areas throughout the United States. A major component of the Section 208 planning is the designation of a management agency (ies) to actually implement the water quality plans for each 208 area. For reasons not dissimilar to water management problem situations in this country, the English and Welsh have recently reorganized their management structure for provision of comprehensive water services. In England and Wales the emphasis is a regional approach for comprehensive water resource planning and management. Detailed information has been presented upon one of the new Regional Water Authorities, the Thames Water Authority. Criteria have been identified which should be of use in evaluating alternative management structures in the context of section 208 management structure efforts. These criteria have been evaluated in a preliminary examination against the present arrangements for provision of water services in three complex urban areas in the United States; Cleveland, Chicago, and Detroit. In addition, the Thames Water Authority has been assessed against these criteria.

77:06A-004
FIELD EVALUATION OF SOME PUBLIC INVOLVEMENT TECHNIQUES,
Ortolano, L., and Wagner, T.P.
Stanford University, Department of Civil Engineering, Stanford, California 94305.
Water Resources Bulletin, Vol. 13, No. 6, p 1131-1139, December 1977. 1 tab, 11 ref.

Descriptors: Water resources, Water resources development, Water law, Planning, Public rights.

Public involvement in water resources planning is receiving much current attention, and there is a need to examine systematically how different public involvement techniques work in practice. The following techniques were among those used to involve the public in a recent Corps of Engineers' study of flooding on San Pedro Creek in Pacifica, California: a public workshop, citizen information bulletins (CIBs) and questionnaires. Interviews were held with 75 study participants to evaluate the effectiveness of these techniques. The interviews indicated that various study participants felt positively about the particular workshop format employed and about the use of a communications specialist to train workshop leaders. There were mixed reactions to the effectiveness of the CIBs and questionnaires. Although many individual citizens felt that the CIBs and questionnaires were useful, some of the Corps planners felt that CIB's and questionnaires would only be "cost-effective" on large studies and/or where the questionnaire response rate was high.

77:06A-005
NEW REQUIREMENTS FOR LOCAL UNITS OF GOVERNMENT IN WATER RESOURCES PLANNING: INSIGHTS FOR IMPLEMENTATION FROM RECENT WATER RESOURCES PLANNING RESEARCH,
Say, E.W., and Dines, A.J.
E.W. Say & Associates, Incorporated, 9741 Liberty Road, Chelsea, Michigan 48118.
Water Resources Bulletin, Vol. 13, No. 5, p 907-915, October 1977. 1 fig, 2 tab, 7 ref.

Descriptors: Water resources, Water resources development, Watersheds, Water law, Environmental effects, Water supply, Water allocation (policy).

Recent Federal and some State legislation has enlarged the scope of permitted or required actions of local units of government in water resources management and protection. Much of the legislation encourages local units of government to introduce water resources planning measures which will be preventive instead of corrective. Extensive public works measures, environmental destruction and the threat to human life can thus be eliminated or reduced. Research has developed and tested a method for identifying the elements of a water resources protection program for small urbanizing watersheds which was technically adequate and socially acceptable to the communities implementing such programs. Research results suggest that deliberate efforts will be necessary to inform and educate local units of government as to the usefulness of the legislation; and that the program must reflect local natural resource conditions and local preferences for the method of accomplishing the protection. Successful implementation could be restrained by inertia of local units of government, a lack of tradition in such programs, and hostile existing agencies.

77:06A-006
ASSESSMENT OF IRRIGATION RETURN FLOW MODELS,
Walker, W.R.
Colorado State University, Department of Agricultural and Chemical Engineering,
Fort Collins, Colorado 80523.
Publication No. EPA-600/2-76-219, October 1976. 75 p, 4 fig, 11 ref, 7 append.

Descriptors: Return flow, Water quality, Model studies, Soils, Aquifer systems, Crops, Application methods, Irrigation, Salinity, Mathematical models, Soil chemistry, Water consumption, Drainage, Leaching.

Throughout the Western United States irrigation return flows contribute to the problem of water quality degradation. Evaluating the effectiveness of alternative management strategies involves models which simulate the processes encompassed by irrigated agriculture. The development and application of these models require multidisciplinary expertise. A workshop involving 15 specialists in the varied aspects of irrigation return flow modeling was held to review the status of these models. Irrigation return flow and conjunctive use models recently developed by the Bureau of Reclamation served as focal points for the workshop. As the field verification and potential applications of these models were discussed, several general problems were identified where further investigation is needed. Particular emphasis was given to the description of the spatially varied aspects of soil, crop, and aquifer systems, and the proper alignment of model objectives with available data. The large number and diversity of existing models illustrate the individualistic nature of irrigation return flow modeling. In order to affect more widespread utilization of existing models, a systematic procedure should be developed to update and disseminate this modeling technology.

SECTION XXIX

WATER RESOURCES PLANNING

EVALUATION PROCESS (GROUP 06B)

77:06B-001
PUBLIC PARTICIPATION IN WATER RESOURCE DEVELOPMENT,
Silberman, E.
Minnesota University, Saint Anthony Falls Hydrology Laboratory, Minneapolis, Minnesota.
Journal of the Water Resources Planning and Management Division, Proceedings of the American Society of Civil Engineers, Vol. 103, No. WR1, Proceedings Paper No. 12952, p 111-123, May 1977. 15 ref.

Descriptors: *Water resources development, *Social participation, *Public benefits, Planning, Social needs, Flood control, Minnesota.

The objectives of a public participation program should be to assure that planners and public have similar concepts of what the problems are and that the proposed solutions are perceived as solutions by both planners and public. Elements of a public participation program are identifying the public, reaching the public, and determining what the public wishes are. These elements are analyzed by recounting the experience of the Bassett Creek Flood Control Commission in establishing a flood control plan for an urbanized and urbanizing area in Minneapolis metropolitan area. The Commission is composed of nine volunteer commissioners, one appointed by each of the nine cities in the basin. The Commission (with the aid of its consulting engineers) was very effective in melding bureaucratic and public input into an acceptable plan where a previous plan prepared under the auspices of a bureaucratic organization was practically shouted down.

77:06B-002
WATER RESOURCES PLANNING AND MANAGEMENT GOALS,
Gaum, C.H.
Corps of Engineers, Central Reports Management Branch, Washington, D.C.
Journal of the Water Resources Planning and Management Division, Proceedings of the Society of Civil Engineers, Vol. 103, No. WR1, Proceedings Paper No. 12941, p 73-82, May 1977. 2 fig, 4 tab.

Descriptors: *Planning, *Decision making, *Priorities, *Management, Water resources development, Water management (applied), Environmental effects, Regions, Projects.

The goal of water resources planning and management is to utilize water related sources for national economic gain, regional development, enhancement of the environment, and the provision of social betterment. It must be recognized that because of great demands, the resources, including dollars, must be economically managed. Only those projects having high justification will be placed in the budget cycle for implementation. Water resources planners must develop new techniques to shorten the time required to plan and foreset priorities. They must improve reporting methods and present all relevant factors. By doing so, they will be playing a more decisive role in the decision-making process.

SECTION XXX

WATER RESOURCES PLANNING

COST ALLOCATION, COST SHARING, PRICING/REPAYMENT (GROUP O6C)

77:O6C-001
CENTER PIVOTS: FINANCING OR LEASING?
LoBello, A.J.
C.I.T. Corporation, National Marketing Division.
Irrigation Journal, Vol. 27, No. 4, p 16-17, July-August, 1977. 1 fig, 1 tab.

Descriptors: Irrigation, Irrigation systems, Sprinkler irrigation, Economics, Financing, Leases.

Center pivot systems are the fastest-growing sector of the irrigation equipment market. Of the two million acres coming under irrigation each year, it is estimated that 60% now are center pivot, with the market growing about 15% each year. At that rate, center pivot can be expected to constitute up to half of the systems in the United States in future years, and a total of some 50 million acres will come under this type of irrigation. Center pivot systems currently run from $30,000 to $60,000 per unit. So, next to the right irrigation system for his needs, the ability to offer a customer the best financing package is one of the most important marketing tools a dealer has.

77:O6C-002
WHICH METHOD IS BEST FOR YOU?: IRRIGATION COSTS,
Water and Irrigation, p 12-13, 24-25, November 1977. 3 fig, 2 tab.

Descriptors: Irrigation systems, Irrigation practices, Economics, Cost analysis, Cost comparisons, Costs, Furrow irrigation, Sprinkler irrigation, Surface irrigation.

One of the most persistent questions in the minds of farmers who are considering changing their method of irrigation, is "What will it cost?" The Cooperative Extension Service of the University of California assigned several of its experts to provide a perspective on irrigation costs in California.

SECTION XXXI

WATER RESOURCES PLANNING

WATER DEMAND (GROUP 06D)

77:06D-001
ARID AND SEMI-ARID LANDS: PROBLEMS AND PROSPECTS,
Kassas, M.
Cairo University, Department of Science, Giza, Egypt.
Agro-Ecosystems, Vol. 3, No. 3, p 185-204, June 1977. 23 ref.

Descriptors: Deserts, Arid lands, Water, Climates, Agriculture, Semiarid climates, Population.

A survey of the world's deserts and processes of desertification identifies those that are strictly due to physical factors and those that are anthropogenic. Areas of potential useful study are identified: Improved climate, climatic research and monitoring, improvement of arid zone cultivars, improved techniques of decision-making about land use. Warnings are given of the dangers of over-intensification of agricultural systems and of increasing population density in arid zones. Research areas suitable for international cooperation are outlined.

77:06D-002
ANALYSIS OF WATER REQUIREMENTS FOR AGRICULTURAL IRRIGATION IN PENNSYLVANIA,
Kibler, D.F., Fritton, D.D., White, E.L., Trotter, R.J., and Tandy, D.F.
The Pennsylvania State University, Institute for Research on Land and Water Resources, University Park, Pennsylvania 16802.
Bureau of Resources Programming, Research Publication 99, September 1977. 228 p, 28 fig, 35 tab, 6 ref.

Descriptors: Irrigation, Crop production, Climates, Irrigation water, Crops, Application methods, Soil moisture, Hydrology, Water demand.

In any study which seeks to project the irrigation water needs for an area, it is important to identify the crops which are likely to be irrigated. Of course, all crops would be listed if the area were located in a desert. In a humid region like Pennsylvania, the decision is not as straightforward. In this report, the objective is to identify the crops which are likely to be irrigated under Pennsylvania's climatic conditions. The decisions in this chapter are made on the basis of the historical use of irrigation research experiments and other carefully documented investigations which apply. The attempt is to base decisions on documented yield increases of a crop under irrigated conditions when compared to yields produced by natural rainfall. Whether these yield increases would pay for an irrigation system is beyond the realm of this study.

SECTION XXXII

WATER RESOURCES PLANNING

WATER LAW AND INSTITUTIONS (GROUP 06E)

77:06E-001
A VALLEY - WIDE SOLUTION,
Beck, L.A.
San Joaquin Valley Interagency Drainage Program, Fresno, California.
Proceedings of National Conference on Irrigation Return Flow Quality Management,
Colorado State University, Fort Collins, Colorado, p 297-298, May 16-19, 1977.

Descriptors: Drainage practices, California, Return flow.

The San Joaquin Valley Interagency Drainage Program (IDP) is an action-oriented program with objectives including: 1) coordination of the on-going drainage water management activities of the cooperating agencies (USBR, SWRCB, and DWR); 2) development of alternative plans for managing the drainage waters; 3) determination of potential uses for drainage waters; 4) development of a recommended plan for managing drainage waters; and 5) recommending ways to finance drainage facilities.

77:06E-002
THE 1973 AGREEMENT ON COLORADO RIVER SALINITY BETWEEN THE UNITED STATES AND MEXICO,
Holburt, M.B.
Colorado River Board of California, Los Angeles, California.
Proceedings of National Conference on Irrigation Return Flow Quality Management,
Colorado State University, Fort Collins, Colorado, p 325-333, May 16-19, 1977.
1 fig.

Descriptors: Water quality, Water quality control, Colorado River, Salinity, Mexico.

The background of the conflict between the United States and Mexico over the salinity of the Colorado River water delivered to Mexico, the early attempts to resolve the conflict, the meetings and negotiations that led to the latest agreements, a description of the agreement, the legislation that implements that agreement, and necessary future actions are presented.

77:06E-003
THE EPA GENERAL PERMIT PROGRAM,
Anderson, K.
United States Environmental Protection Agency, Washington, D.C.
Proceedings of National Conference on Irrigation Return Flow Quality Management,
Colorado State University, Fort Collins, Colorado, p 397-404, May 16-19, 1977.

Descriptors: Agriculture, Water quality, Water quality control, Irrigation, Return flow.

The Environmental Protection Agency (EPA) has developed a General Permit Program under the National Pollutant Discharge Elimination System (NPDES) which applies to both separate storm sewers and agricultural point sources (irrigation return flow conveyances). The proposed rules for this general permit program were printed in the Federal Register, Vol. 42, No. 24, February 4, 1977. This paper provides a guide as to how the General Permit Program is intended to function.

77:06E-004
INTERFACE OF WATER QUANTITY AND QUALITY LAWS IN THE WEST,
Radosevich, G.E.
Colorado State University, Department of Economics, Fort Collins, Colorado
80523.
Proceedings of National Conference on Irrigation Return Flow Quality Management,
Colorado State University, Fort Collins, Colorado, p 405-422, May 16-19, 1977.
1 tab.

Descriptors: Water law, Water pollution, Agriculture, Return flow, Water quality, Water quality control, Water resources, Water rights, Irrigation.

Water pollution from irrigated agriculture in the West has received major attention during the past five years, primarily as a result of federal and state endeavors to identify irrigation return flow quality problems and to develop a viable control strategy. The national goal of "cleaner water" emerged as a result of the deterioration of water quality by degraded discharges from various sources. The key to irrigated agricultural return flow quality control is proper utilization and managment of the resource itself, and an accepted tool in our society is the law. By legal classification, it is divided into laws for quantity control and laws for quality control. The laws on water quality control are recent, relatively uniform between states and with little exception, constrain improvement of return flows from irrigated agriculture. Unfortunately, in most others, they cannot really be said to facilitate this consequence either. The laws pertaining to water resources quantity control and management are complex, voluminous, inconsistent and lack uniformity among the 17 states of the West.

77:06E-005
AN INFLUENT CONTROL APPROACH TO IRRIGATION RETURN FLOW QUALITY MANAGEMENT,
Radosevich, G.E., and Skogerboe, G.V.
Colorado State University, Department of Economics, Fort Collins, Colorado 80523.
Proceedings of National Conference on Irrigation Return Flow Quality Management,
Colorado State University, Fort Collins, Colorado, p 423-434, May 16-19, 1977.
5 fig.

Descriptors: Water quality control, Agriculture, Water quality, Irrigation, Return flow, Water rights.

The Influent Control Approach is based upon the assumption that improved water management plus improved agricultural practices will significantly contribute to improved water quality, and the conclusion that best management practices plus best agricultural practices will provide irrigation return flow quality control, which in turn will contribute significantly to the national goal of cleaner water through improved water quality. The Influent Control Approach consists of eight specific components: (1) designate areas for irrigation return flow quality management and designate the responsible area entity; (2) develop standards and criteria for beneficial use in designated areas; (3) introduce incentives to use water more efficiently; (4) include the element of water quality in new or transferred and changed water rights; (5) adopt and enforce a reporting and recording system for water rights; (6) recognize reasonable degradation from agricultural water use; and (7) adopt an Agricultural Practices Act; and (8) promote close cooperation or integration of state water agencies and related functions.

77:06E-006
ECONOMIC IMPACTS OF ADMINISTRATIVE WATER LAW SYSTEMS,
Kiker, C.P.E., and Lynne, G.D.
Florida University, Department of Food and Resource Economics, Gainesville,
Florida.
Presented at the 1977 Annual Meeting of the American Society of Agricultural
Engineers, June 26-29, 1977, Raleigh, North Carolina, North Carolina State
University, p 1-22. 20 ref, 13 equ.

Descriptors: Legal aspects, Legislation, Water law, Economics.

There is a move to administrative regulation of water in the eastern states. Economic efficiency is largely being ignored in allocation of private entitlements to water. Several allocation alternatives that include economic criteria are examined.

77:06E-007
SOIL EROSION AND SEDIMENTATION: ANALYSIS OF APPLICABLE LAW,
Walker, W.R., and Cox, W.E.
Virginia Water Resources Research Center, Blacksburg, Virginia.
Presented at the Annual Meeting, American Society of Agricultural Engineers,
June 26-29, 1977, Raleigh, North Carolina, North Carolina State University,
p 1-12. 16 ref.

Descriptors: Soil erosion, Erosion, Sedimentation, Legislation, Legal aspects.

Law applicable to activities that increase erosion and sedimentation exists in a variety of forms. The trend in the development of such law has been toward an expansion in scope of activities encompassed and an increase in the degree of legal accountability imposed for resulting injury.

77:06E-008
EXPERIENCE WITH THE 303-208-201 STUDY RELATIONSHIPS,
Dobrowolski, F., and Grillo, L.
Clinton Bogert Associates, Fort Lee, New Jersey 07024.
Water Resources Bulletin, Vol. 13, No. 3, p 455-460, June 1977.

Descriptors: New Jersey, Municipal water, Water quality, Water quality control, Water pollution, Water quality standards, Water resources.

The current 201 study by the Bergen County Sewer Authority illustrates possibilities for improving the currently defined relationships between 201, 208 and 303 studies. The Bergen County Sewer Authority serves 115 square miles in northeast New Jersey, providing sewerage service to 507,000 people in 43 municipalities. Its STP discharges to the Hackensack River, a tidal estuary recently classified as Water Quality Limited, and which receives significant nonplant loading. The subject 201 study is concurrent with 208 and 303 planning by NJDEP. Preliminary evaluations show that detailed 201 work can affect the conclusions of 303 and 208 studies, and that a wider (environmental-social as well as economic) interpretation of cost-effectiveness can demand reexamination of prior assumptions and decisions, a task not typically part of 208-303 work.

77:06E-009
INVESTOR OWNED VS. PUBLICLY OWNED WATER AGENCIES: AN EVALUATION OF THE PROPERTY RIGHTS THEORY OF THE FIRM,
Morgan, W.D.
California University, Department of Economics, Santa Barbara, California 93106.
Water Resources Bulletin, Vol. 13, No. 4, p 775-781, August 1977. 2 tab, 8 ref,
1 equ.

Descriptors: Water, Water resources, Water law, Water costs, Water allocation (policy).

The property rights theory of the firm is evaluated by comparing the cost structures of a sample of water agencies under two alternative modes of ownership - public and investor owned. On the basis of the sample, investor owned water agencies appear to have lower cost structures.

77:06E-010
DEVELOPING COMPETITION FOR WATER IN THE URBANIZING AREAS OF COLORADO,
Anderson, R.L., and Wengert, N.I.
Colorado State University, Department of Economics, Fort Collins, Colorado 80523.
Water Resources Bulletin, Vol. 13, No. 4, p 769-773, August 1977. 2 tab, 1 ref.

Descriptors: Colorado, Water resources, Water allocation (policy), Irrigation water, Agriculture, Municipal water, Water supplies.

Rapid population growth in the metropolitan area of Denver, Colorado, is causing conflicts over water use. Two cities, Thornton and Westminster, have begun condemnation proceedings against three irrigation companies to secure agricultural water rights for municipal use. This is the first condemnation proceeding against irrigation water rights for municipal use. Should the suit succeed, over 30,000 acres of presently irrigated land will lose its water supply. There are about four hundred landowners in the area; two hundred of these are commerical farmers, including truck, dairy and specialty farms. Total agricultural production amounts to about $8 million per year. About 561 jobs related to agriculture will disappear along with about $4 million in net income.

77:O6E-011
WATER RIGHTS, EMINENT DOMAIN, AND THE PUBLIC TRUST,
Radosevich, G.E., and Sabey, M.B.
Colorado State University, Department of Economics, Fort Collins, Colorado 80521.
Water Resources Bulletin, Vol. 13, No. 4, p 747-757, August 1977. 12 ref.

Descriptors: Water law, Water resources, Water allocation (policy), Agriculture, Colorado, Municipal water, Irrigation water.

Faced with the necessity of meeting growing municipal water requirements in areas where available supplies are completely allocated, numerous cities throughout the West are turning to their eminent domain powers to affect a reallocation of water from less preferred uses to municipal uses, thus bringing about a sharp conflict with agricultural interests. As a basis for discussing these eminent domain powers, this paper begins with a brief review of the development of property rights. The existence of both private and public (social) rights in the "bundle of rights" is noted. In recent years the Public Trust Doctrine has been used to limit private rights in property, and to protect and strengthen social rights. A case study which focuses on a conflict between individual and social interests in water rights is discussed. This case involves the City of Thorton, Colorado which initiated municipal condemnation proceedings to acquire the water rights and structures of two nearby irrigation companies. The case represents an attempt to incorporate the spirit of the Public Trust Doctrine into legislation which sets forth procedures for resolution of similar water rights conflicts that will inevitably become more numerous throughout the West in the future.

77:O6E-012
IRRIGATION TECHNOLOGY AND AGRICULTURE PRODUCTION,
Logan, D.
Western Empire Corporation, Irrigon, Oregon.
Proceedings of the 1977 Annual Technical Conference, Irrigation For All Reasons, p 178-180, February 13-15, 1977.

Descriptors: Irrigation, Irrigation practices, Irrigation effects, Agriculture, Crop production, Oregon.

An irrigation farmer elaborates on his views of irrigated agricultural development and irrigation technology.

77:O6E-013
WINTER'S DOCTRINE: A REVIEW,
Bird, J.W.
Nevada University, Department of Civil Engineering, Reno, Nevada.
Journal of the Irrigation and Drainage Division, Vol. 103, No. IR4, p 395-400, December 1977. 9 ref, 1 append.

Descriptors: Appropriation, Beneficial use, Federal government, State government, Water law, Water rights.

The western states are areas of short water supply. In general, they apply the water law doctrine of appropriation that relates a water right to the time or date that the right started. The Federal government has applied for water rights at a much later time, but with an early appropriation date. This would give the Federal agencies priority over the existing water users, many of which have been beneficially using the water for years. Since the Federal agencies apparently have decided, through the courts, their ability to act unilaterally in this matter, it is apparent that guidance from the Congress is sorely needed in this matter. Otherwise the state's water laws shall be greatly weakened, along with state water planning and policy.

77:06E-014
ON THE ALLOCATION OF PRIME AGRICULTURAL LAND,
Gibson, J.A.
Harza Engineering Company, Department of Economics, 150 South Wacker Drive,
Chicago, Illinois 60606.
Journal of Soil and Water Conservation, Vol. 32, No. 6, p 271-275, November-December, 1977. 27 ref.

Descriptors: Land, Land classification, Land development, Land management, Land resources, Land use, Agriculture, Environment, Environmental control, Economics, Urbanization.

How land is used in the future likely will vary considerably from how land should be used according to economic theory. Asymmetry characterizes the effectiveness and efficiency of our system of economic incentives. A major part of land use is formed by the sum of many individual local actions. The present market system stimulates the exploitation of land resources very well, but it fails almost completely with respect to preservation. For example, climate, topography, and soils exert all-important effects upon the use of land for agricultural purposes. The location factor is of little significance for agriculture in the absence of a suitable physical base.

SECTION XXIII

RESOURCES DATA

DATA ACQUISITION (GROUP 07B)

77:07B-001
AN EVALUATION OF SOME FLUORESCENT DYES FOR WATER TRACING,
Smart, P.L., and Laidlaw, I.M.S.
Bristol University, Department of Geography, (England).
Water Resources Research, Vol. 13, No. 1, p 15-33, February 1977. 19 fig, 11 tab, 77 ref.

Descriptors: *Fluorescent dye, *Water chemistry, *Tracers, *Dyes, Water, Amino acids, Rhodamine, Laboratory tests, Toxicity, Filters, On-site tests.

Eight fluorescent dyes (amino G acid, photine CU, fluorescein, lissamine FF, pyranine, rhodamine B, rhodamine WT, and Sulpho rhodamine B) were compared in laboratory and field experiments to assess their utility in quantitative tracing work. The properties considered included sensitivity and minimum detectability, the effect of water chemistry on dye fluorescence, photochemical and biological decay rates, adsorption losses on equipment and sediments, toxicity to man and aquatic organisms, and cost. The orange fluorescent dyes are more useful than the blue and green dyes because of the lower background fluorescence at the orange wave band, which permits higher sensitivities to be obtained. Pyranine fluorescence is strongly affected by pH over the range encountered in natural waters, which precludes its simple use in quantitative work. Amino G acid, photine CU, pyranine, and fluorescein all have high photochemical decay rates. Pyranine, lissamine FF, and amino G acid are the dyes most resistant to adsorption, but rhodamine WT, fluorescein, and sulpho rhodamine B also have moderately high resistance. Rhodamine B is readily adsorbed by most materials. Rhodamine WT (orange), lissamine FF (green), and amino acid G acid (blue) are the three tracer dyes recommended. These 3 dyes can be used simultaneously to trace three injection sites with the filter combinations suggested.

77:07B-002
TWO NEW METHODS FOR OBTAINING WATER SAMPLES FROM SHALLOW AQUIFERS AND LITTORAL SEDIMENTS,
John, P.H., Lock, M.A., and Gibbs, M.M.
Department of Scientific and Industrial Research, Ecology Division; and Department of Scientific and Industrial Research, Freshwater Section, Taupo (New Zealand).
Journal of Environmental Quality, Vol. 6, No. 3, p 322-324, July-September, 1977. 5 fig, 6 ref.

Descriptors: *Water sampling, *Aquifers, *Sediments, *Littoral, Groundwater, Methodology, Instrumentation, Monitoring, Geochemistry, Wellpoints, Plastic pipes, Water table, Nutrients, Foreign research.

Two sampling techniques were developed which enable groundwater samples to be obtained from various depths within shallow aquifers and littoral sediments. Both techniques involve the insertion of a percussion-driven spike to the desired depth. One method employs a sampling probe consisting of a perforated tip and a mechanism for the prevention of blockage by grit during the driving process, with samples being withdrawn through an internal plastic tube. The other technique involves permanent installation of a perforated plastic tubing. Some examples of chemical data obtained during extensive testing of these techniques were presented. It was concluded that the techniques could have considerable application in the investigation of shallow groundwater and littoral sediment chemistry.

77:07B-003
CLOVER N-FIXATION MEASUREMENT BY TOTAL-N DIFFERENCE AND 15N A-VALUES IN LYSIMETERS,
Williams, W.A., Jones, M.B., and Delwiche, C.C.

California University, Department of Agronomy, Davis, California.
Agronomy Journal, Vol. 69, No. 6, p 1023-1024, November-December, 1977. 1 fig, 1 tab, 6 ref.

Descriptors: Nitrogen, Legumes, Leaching, Lysimeters, Clovers, California, Crop production, Crop response.

Assessment and improvement of N fixation by legumes on annual-type range is becoming increasingly important in light of the increasing need for energy conservation. A comparison was made of two methods of assessing N fixation: a simple but crude method by measuring the total-N difference in tops of an N-fixing legume and a non N-fixing grass, and a more expensive method using A-values determined from 15N applications to the same legume and grass species. Subterranean clover and soft chess grass were grown in field lysimeters (69 cm deep by 36 cm diam.) filled with Josephine loam (Typic Haplozerults, fine loamy, mixed mesic) for 3 years. Single (100 and 500 kg/ha) and repeated (100 kg/ha) applications of 15N were made and determinations were made of soil and fertilizer N in the plants, soil, and leachate periodically. The relation between the two methods was strongly linear; fixation (kg/ha) by the A-value method = 50.1 + 0.852 N fixation by difference (r = 0.98, n = 15). Consequently, previous values cited for N fixation measured by the difference method for winter annual legumes in California may have been underestimated by about 40%.

77:07B-004

EVALUATION OF A WATER ANALYSIS KIT,

Boyd, C.E.
Auburn University, Department of Fisheries and Allied Aquaculture, Auburn, Alabama 36830.
Journal of Environmental Quality, Vol. 6, No. 4, p 381-384, October-December, 1977. 3 tab, 10 ref.

Descriptors: Laboratory tests, Laboratory equipment, Water analysis, Water chemistry, Water pollution, Water pollution control, Water quality, Water quality control.

A Hach DR-EL/2 Direct Reading Engineer's Laboratory Kit was evaluated by comparison to standard analytical methods. Results of Hach kit methods were highly correlated with concentrations of standard solutions. The y-intercepts (a) did not differ from 0 for most methods, but for 11 methods regression coefficients (b) differed from 1.0. For each of the 20 parameters, three natural water samples were analyzed seven times by Hach kit and by the standard method. Mean values obtained by the two analytical systems were usually significantly different and the standard method sometimes gave higher precision than the Hach kit. Nevertheless, the Hach kit usually gave close approximations of values obtained by standard methods. Comparisons also included analyses of a large series of natural water samples. Correlation coefficients between Hach kit and standard methods were often greater than 0.00. Although a = 0 for 14 methods, b = 1.0 for only 8 methods. Reliability of the Hach kit was adequate for general surveys of water quality, fisheries management decisions, and research requiring only approximate data on water quality.

77:07B-005

INTEGRATED AUTOMATIC WATER SAMPLE COLLECTION SYSTEM,

Fisher, P.D., and Siebert, J.E.
Michigan State University, Department of Electrical Engineering and Systems Science, East Lansing, Michigan.
Journal of the Environmental Engineering Division, American Society of Civil Engineers, Vol. 103, No. EE4, p 725-728, August 1977, 3 fig.

Descriptors: *Water sampling, *Data collections, *Equipment, Stream gages, Sampling, Water chemistry, Water pollution, Hydrologic data, Automation, Electrical equipment, Electronic equipment, Hydrographs, Hydrology.

Reported in this paper were the organizations, operation, and utility of an automatic water sample collection, a modified hydrographic recorder, and a specially designed auxiliary electronic controller. The integrated water sampling system expands the normal operating capabilities of the conventional automatic water sampler and hydrographic recorder.

77:07B-006
SOIL SALINITY--FOUR-ELECTRODE CONDUCTIVITY RELATIONSHIPS FOR SOILS OF THE NORTHERN GREAT PLAINS,
Halvorson, A.D., Rhoades, J.D., and Reule, C.A.
United States Department of Agriculture--Agricultural Research Service, Department of Soil Science, Post Office Box 1109, Sidney, Montana 59270.
Soil Science Society of America Journal, Vol. 41, No. 5, p 966-971, September-October, 1977. 4 fig, 5 tab, 12 ref.

Descriptors: Soils, Soil investigations, Salinity, Saline soils, Soil textures, Electrical conductance, Clays, Soil water, Soil moisture.

Influence of soil texture, soil geographic location and parent material, and calibration method on the linear ECe-ECa relationship was investigated. Linear regression relationships between saturation extract electrical conductivity (ECe) and bulk soil electrical conductivity (ECa) as measured by the four-electrode technique was developed for northern Great Plains soils. Most correlation coefficients (r) exceeded 0.95 and all were significant at the 0.01 probability level. Geographic location had little effect on the ECe vs. ECa relationship; therefore, an ECe vs. ECa calibration made for a soil textural class at one location will apply to another location having a similar range in soil water, clay content, and salinity. Clay content affected linear regression line slopes more than did other factors investigated. Regression slopes varied from 3.06 for a clay to 12.99 for a loamy sand over the clay concentration range of 63.0 to 6.5 percent, respectively. To minimize adverse effects caused by natural variation in soil texture, water content, and salinity when making field ECe vs. ECa calibrations, we suggest artificial salinization of columns of the soil type in question, which will permit subsequent analysis of the soil by either the cell or EC-probe calibration method.

77:07B-007
A LABORATORY TECHNIQUE FOR APPRAISING IN SITU SALINITY OF SOIL,
Mubarak, A., and Olsen, R.A.
Montana State University, Department of Chemistry, Bozeman, Montana.
Soil Science Society of America Journal, Vol. 41, No. 5, p 1018-1020, September-October, 1977. 2 fig, 2 tab, 14 ref.
(See 77:02G-083)

77:07B-008
GAS CHROMATOGRAPHIC ANALYSIS OF SOIL ATMOSPHERES,
Blackmer, A.M., and Bremner, J.M.
Iowa State University, Department of Agronomy, Ames, Iowa 50011.
Soil Science Society of America Journal, Vol. 41, No. 5, p 908-912, September-October, 1977. 4 fig, 2 tab, 25 ref.

Descriptors: Sampling, Soil investigations, Soils, Soil environment, Soil properties, Soil tests.

A gas chromatographic procedure is described that permits rapid, specific, and precise determination of N2, O2, Ar, CO2, CH4, N2O, and other gases in soil atmospheres. It involves use of an ultrasonic detector and two columns of Porapak Q at different temperatures, and it does not require temperature programming, column conditioning, stream splitting, column switching, or switching of recorder polarity. Unlike thermal conductivity and helium ionization detectors previously used for gas chromatographic analysis of soil atmospheres, the ultrasonic detector is not adversely affected by gases found in soil atmospheres.

77:07B-009
A COMPARISON OF DETERMINISTIC MATHEMATICAL WATERSHED MODELS,
Perrier, E.R., Harris, J., and Ford, W.B.
United States Army Engineer District, Environmental Effects Laboratory, Vicksburg, Mississippi.
Presented at the 1977 Annual Meeting, American Society of Agricultural Engineers, June 26-29, 1977, Raleigh, North Carolina, North Carolina State University, p 1-33. 10 fig, 3 tab, 13 ref, 1 append.

Descriptors: Simulation analysis, Model studies, Watershed management, Watersheds (basins).

Hydrocomp, SWM, SSARR, HEC-1 and United States Department of Agriculture-HL75 were reviewed using input data from the Caddo River drainage basin for mathematical simulation comparisons. The attributes of each model are presented permitting the selection of a model most appropriate for a specific application to chemical washoff algorithms.

77:07B-010
IRRIGATION RETURN FLOW MODELING--A STATE OF THE ART,
Walker, W.R.
Colorado State University, Department of Agricultural and Chemical Engineering, Fort Collins, Colorado 80523.
Presented at the 1977 Winter Meeting of the American Society of Agricultural Engineers, December 13-16, 1977, Palmer House, Chicago, Illinois, p 1-18. 4 tab, 54 ref.

Descriptors: Return flow, Model studies, Simulation analysis, Computer programs, Groundwater, Nitrogen, Irrigation, Irrigation effects.

Forty-three models which have been developed and tested for simulation of irrigation return flow systems have been collected and evaluated. This paper discusses what seems to be some of the more critical problems in using these models, the relative strengths of those existing, and important research and development needs for maximizing their utilization in the future.

77:07B-011
RAINFALL SIMULATOR FOR EVALUATING EROSION RATES AND SEDIMENT SIZES FROM ROW SIDESLOPES,
Meyer, L.D., and Harmon, W.C.
United States Department of Agriculture Sedimentation Laboratory, Department of Agricultural Engineering, Oxford, Mississippi.
Presented at the 1977 Annual Meeting, American Society of Agricultural Engineers, June 26-29, 1977, Raleigh, North Carolina, North Carolina State University, p 1-12. 9 fig, 8 ref.

Descriptors: Rainfall, Simulation analysis, Rainfall simulators, Runoff, Erosion, Sediments, Sedimentation, Soil erosion.

A new rainfall simulator was developed for obtaining data on row-sideslope runoff, erosion, and sediment size. It can apply a wide range of intensities at impact energies comparable to those of natural rainfall. Design features, simulated-rainfall characteristics, and example data are reported.

77:07B-012
A NEW APPROACH TO DETERMINATION OF CATION EXCHANGE CAPACITY,
Fernando, M.J., Burau, R.G., and Arulanandan, K.
California University, Davis, California.
Soil Science Society of America Journal, Vol. 41, No. 4, p 818-820, July-August, 1977. 3 fig, 2 tab, 8 ref.

Descriptors: Sampling, Laboratory tests, Cation exchange, Soils, Soil texture, Soil investigations, Soil properties.

The dielectric dispersion defined as the difference in the dielectric constant of a sample measured at 3,000,000 HZ and at 75,000,000 HZ, was linearly related to CEC of the sample. One linear relationship between dielectric dispersion and CEC was obtained for clay-silica flour mixtures where CEC was varied by changing the proportion of clay in the sample as well as by using clays with different CEC (kaolinite, illite, montmorillonite). A second linear relationship, with somewhat different slope, was obtained between the dielectric dispersion and the CEC of natural soil samples.

77:07B-013
CORRECTING TURBIDITY INTERFERENCE IN THE DETERMINATION OF PHOSPHORUS,
Folsom, B.L., Jr., Sunderman, H.D., and Hossmer, L.R.
Texas Agricultural Experiment Station, College Station, Texas.

Soil Science Society of America Journal, Vol. 41, No. 4, p 823-824, July-August, 1977. 2 fig, 11 ref.

Descriptors: Phosphorus, Ammonium, Turbidity, Sampling, Laboratory tests.

Turbidity caused severe interference in the presence of excess ammonium when determining phosphorus by the method of Murphy and Riley. The precipitated complex was isolated and found to be composed of NH4(+), antimony, P, and molybdenum in a ratio of 115.8:1.5:1.0:11.6. The combination of Sb and NH4(+) in solution during color development caused the turbidity interference. The turbidity could be eliminated by raising the pH above 8.2 with NaOH and boiling to drive off NH4(+) as NH3 gas prior to color development or by substituting heat for Sb to develop the characteristic molybdenum blue color.

77:07B-014
PHOTOSYNTHESIS OF SUGARBEETS UNDER N AND P STRESS: FIELD MEASUREMENTS AND CARBON BALANCE,
Cary, J.W.
Snake River Conservation Research Center, Department of Soil Science, Kimberly, Idaho 83341.
Agronomy Journal, Vol. 69, No. 5, p 739-744, September-October, 1977. 7 fig, 1 tab, 10 ref.

Descriptors: Crop production, Photosynthesis, Sugar beets, Phosphorus, Nitrogen, Carbon, Crop response, Nutrients, Fertilizers, Fertilization.

Advances in crop management are limited by inability to recognize changes in growth resulting from short-term fluctuations in plant environment. Simple, rapid, and nondestructive methods are needed to indicate daily and hourly rates of growth under field conditions. Because plant carbon balance is one possible approach to this problem, CO2 gas exchange parameters were measured on Beta vulgaris leaves of field-grown plants to learn whether or not they might signal the onset of nitrogen and P stresses. The sugarbeets were grown on field plots of Portneuf silt loam soil and allowed to develop severe N and P stresses. Carbon dioxide exchange and stomatal resistance of intact plant leaves were measured with small leaf chambers during 1 minute periods. Leaf water potentials were also measured in the field with a hydraulic press. The CO2 compensation points, dark respiration, and osmotic pressures of excised leaf tissue were measured in the laboratory by standard methods. Photosynthesis per unit leaf area was reduced in advanced stages of N deficiency; however, none of the measurements satisfactorily indicated the onset of N or P stress because of heterogeneity between leaves.

77:07B-015
MISCIBLE DISPLACEMENT OF NITRATE AND CHLORIDE UNDER FIELD CONDITIONS,
Misra, C., and Mishra, B.K.
Orissa University of Agriculture and Technology, Dryland Agricultural Research Project, Bhubaneswar-751003, India.
Soil Science Society of America Journal, Vol. 41, No. 3, p 496-499, May-June, 1977. 2 fig, 1 tab, 13 ref, 5 equ.

Descriptors: Nitrates, Nutrients, Fertilization, Fertilizers, Leaching, Soil water, Soil water movement, Irrigation effects, Denitrification.

In an attempt to develop the capability for predicting the reduction loss of NO3(-)N during leaching of nitrate fertilizers in an Oxisol field profile, a 2-cm pulse of Ca(NO3)2 solution containing 304 ppm of NO3(-)N was displaced through a 300-cm by 300-cm field plot saturated with water down to the depth of 55 cm. On the following day an identical pulse of NH4Cl solution containing 795 ppm of Cl was leached through the same plot. The results were analyzed by means of a convective diffusion type transport equation that incorporated an irreversible first-order sink term.

77:07B-016
MEASUREMENT OF SOIL GASEOUS DIFFUSION COEFFICIENTS BY A TRANSIENT-STATE METHOD WITH A TIME-DEPENDENT SURFACE CONDITION,
Rolston, D.E., and Brown, B.D.

California University, Department of Land, Air and Water Resources, Davis, California 95616.
Soil Science Society of America Journal, Vol. 41, No. 3, p 499-505, May-June, 1977. 8 fig, 2 tab, 11 ref, 7 equ.

Descriptors: Soils, Soil investigations, Soil properties, Soil gases, Denitrification, Nitrogen, Soil profiles.

Precise measurement of the gaseous diffusion coefficient in soils is necessary for calculating the flux of gas resulting from soil respiration, denitrification, or fumigation. Gaseous diffusion coefficients of soil columns and a field soil were determined by fitting a solution of the transient-state diffusion equation for a time-dependent surface condition to measured N2 concentration profiles. The time-dependent surface condition was experimentally imposed by pumping argon at a constant rate into a chamber placed within the soil and on the soil surface. The argon and air mixture exited the chamber through several exit ports. The N2 concentration at the soil surface and within the soil profile was determined several times within a 5-hour period after initiation of the argon flow. A solution of the diffusion equation for a nonconstant initial condition can also be used for determining the diffusion coefficient for cases where the initial gas concentration is not constant with depth. Diffusion coefficients for a field soil determined from the transient-state solutions compared favorably with those determined from laboratory measurements on undisturbed soil cores and field measurements of CO2 flux.

77:07B-017

THE ASSESSMENT OF PLANT-AVAILABLE CADMIUM IN SOILS,

Symeonides, C., and McRae, S.G.
Wye College (London University), Department of Physical Sciences, Ashford, Kent, England.
Journal of Environmental Quality, Vol. 6, No. 2, p 120-123, April-June, 1977. 2 fig, 4 tab, 35 ref.

Descriptors: Cadmium, Heavy metals, Soils, Soil investigations, Water quality, Pollution, Crop response.

A study has been made of the amounts of cadmium recovered by a variety of reagents and extraction procedures from soils to which Cd has been added. Correlation of these results with the Cd content of radish plants grown in these soils has shown that the most sensitive of several possible indices to Cd uptake by plants is the amount extracted by a 1-hour shaking with 1N ammonium nitrate solution at a soil/solution ratio of 1:10 (wt/vol). The greater efficiency of this extractant compared with other proposed extractants is ascribed to the system reflecting the natural pH of the soil which has a marked effect on cadmium availability to plants.

77:07B-018

DETERMINATION OF ORTHOPHOSPHATE IN AQUEOUS SOLUTIONS CONTAINING LABILE ORGANIC AND INORGANIC PHOSPHORUS COMPOUNDS,

Dick, W.A., and Tabatabai, M.A.
Iowa University, Department of Agronomy, Ames, Iowa 50011.
Journal of Environmental Quality, Vol. 6, No. 1, p 82-85, January-March, 1977. 4 fig, 3 tab, 16 ref.

Descriptors: Sampling, Water quality, Water quality control, Phosphorus, Laboratory tests, Fertilizers, Nutrients.

A simple and precise colorimetric method of determining orthophosphate in aqueous solutions containing labile organic and inorganic P compounds is described. It involves a rapid formation of molybdenum blue color by the reaction of orthophosphate with molybdate ions in the presence of ascorbic acid-trichloroacetic acid and citrate-arsenite reagents and complexation of the excess molybdate ions to prevent further formation of blue color from the phosphate derived from hydrolysis of the acid-labile P compounds. The color is stable up to 24 hours. The method is sensitive and accurate, and it permits determination of microgram quantities of orthophosphate in samples containing large amounts of acid-labile P compounds. Tests with a wide range of condensed phosphate and organic phosphate compounds showed that none of the P compounds studied interfered with this method. Results by this method are compared with those obtained by the method of Murphy and Riley.

77:07B-019
A SELF-PROPELLED HIGH-CLEARANCE SOIL CORING MACHINE,
Bausch, W., Onken, A.B., Wendt, C.W., and Wilke, O.C.
Texas A and M University, Texas Agricultural Experiment Station, Agricultural Research and Extension Center, Lubbock, Texas.
Agronomy Journal, Vol. 69, No. 1, p 122-124, January-February, 1977. 4 fig, 1 tab, 6 ref.

Descriptors: Sampling, Crop production, Soil investigations, Soils, Soil tests, Soil profiles, Soil properties.

Mechanical soil sampling equipment currently available is suitable for sampling prior to crop establishment or in low grouping crops but cannot be used without plant damage in some tall crops. A self-propelled high-clearance soil coring machine was designed and constructed to obtain soil samples in a tall standing crop at a range of lateral as well as vertical distances. The sampler is hydraulically operated and has vertical pressure and rotary drilling capabilities. This equipment has a lateral travel span of 152 cm and the capability of coring to a depth of 9 m with the mast in any lateral position on the track. Two operators can use the sampler without difficulty; however, three operators are desirable if a large number of samples are to be taken. As many as eighty 30-cm increment soil samples have been taken per hour when sampling a moist sandy soil to a depth of 2 m.

77:07B-020
SOIL NITRATE-NITROGEN DETERMINED BY CORING AND SOLUTION EXTRACTION TECHNIQUES,
Alberts, E.E., Burwell, R.E., and Schuman, G.E.
United States Department of Agriculture-Agricultural Research Service, West Lafayette, Indiana.
Soil Science Society of America Journal, Vol. 41, No. 1, p 90-92, January-February, 1977. 1 fig, 1 tab, 13 ref.

Descriptors: Nitrates, Nitrogen, Sampling, Soil profiles, Soil tests, Iowa, Leaching.

Soil-coring and solution-extraction sampling techniques were compared for determining the content of NO3(-)N in the soil profile of a Monona silt loam in southwestern Iowa. The NO3(-)N content of the 3.05-m profile, determined by solution extraction, was 28% lower in 1972, 8% higher in 1973, and 13% lower in 1974 than that determined by soil coring. The profile difference in NO3(-)N content between the two sampling techniques was insignificant in 1973 and 1974 but was highly significant (1%) in 1972.

77:07B-021
DIGITAL ELECTRONIC MEASUREMENT AND RECORDING OF IRRIGATION FIELD WATER DEPTHS,
Dawes, W.H., Casey, M.R., Scharplaz, J.D., and Manges, H.L.
ICE Corporation, Manhattan, Kansas 66502.
Presented at the 1977 Winter Meeting of the American Society of Agricultural Engineers, December 13-16, 1977, Palmer House Hotel. Chicago, Illinois, p 1-3. 1 fig.

Descriptors: Furrow irrigation, Water table, Sampling, Irrigation practices, Irrigation effects.

This presentation describes a system for measuring water depths at twelve locations in a three-furrow irrigation field with capacitance type level sensors. The data from the sensors is recorded on a cassette tape at one or five minute intervals. The system is battery operated. Methods for retrieving data from a cassette tape are discussed.

77:07B-022
MARINE DYNAMICS AND ITS EFFECT ON CURRENT MEASURING TRANSDUCERS,
Mero, T., and Appell, G.
Test and Evaluation Laboratory, National Oceanic and Atmospheric Administration.
Proceedings of the Symposium on Flow Measurement in Open Channels and Closed Conduits, Gaithersburg, Maryland, p 109-121, February 23-25, 1977. 3 fig, 3 tab, 3 ref.

Descriptors: Velocity, Flow measurement, Currents (water), Turbulence, Turbulent flow, Dynamics.

A growing interest in measuring current velocities in coastal zone and estuaries prompted the creation of a Dynamic Analysis Program at T&EL (formerly NOIC). The dynamics of near-shore current flows are more severe than that of the deep ocean. Therefore, it is important to qualify the performance of current measuring transducers in a dynamic environment. A study was contracted to determine what scales and intensities of turbulence exist in the near-shore environment. The major effort of the study is concerned with turbulence from 1 to 20 Hz and scales up to 30 cm. Tests are being conducted to determine the response characteristics of several current measuring transducers including both rotor and electromagnetic instruments. These tests include grid-produced turbulence measurements as well as simulated mooring-line dynamics' tests. Measurements have revealed several transducers that have 10 to 20% sensitivity increases when turbulence intensities of 6 to 12% are present. This paper contains a description of turbulence that exists in the marine environment along with dynamic response characteristics of several current measuring transducers.

77:07B-023
A NEW DIELECTRIC SOIL MOISTURE METER FOR FIELD MEASUREMENT OF SOIL MOISTURE,
Kuraz, E.V., and Matousek, J.
Technical University, Department of Irrigation and Drainage, Karlova nam, 3, Praha 2.
International Commission on Irrigation and Drainage, Vol. 26, No. 1, p 76-79, January 1977. 3 fig, 5 ref.

Descriptors: Soil moisture, Soil water, Soil properties, Bulk density, Sampling.

A new apparatus for the soil moisture measurement in field conditions by a dielectric method has been developed. The arrangement is based on the principle of the capacitance--frequency convertor. With a good operating reliability and temperature stability, a miniaturization of the device has been reached. The apparatus works in the whole range of moisture content, the measurement is also influenced by the change of bulk density. The temperature change is irrelevant and the sensitivity to the change of the chemical composition is low. The measuring procedure is very simple, the reading is possible either on the scale, or a registering apparatus can be connected. For each soil a calibration curve has to be determined.

77:07B-024
ERRORS IN FLOW MEASUREMENT AND THEIR IMPORTANCE IN INFILTRATION/INFLOW ANALYSIS,
Guthrie, D.L., Washington, D.R., and Vincenty, C.
Environmental Quality Systems, Incorporated, Rockville, Maryland.
Proceedings of the Symposium on Flow Measurement in Open Channels and Closed Conduits, Gaithersburg, Maryland, p 173-200, February 23-25, 1977. 7 fig, 2 tab, 10 ref, 2 equ.

Descriptors: Flow measurement, Infiltration, Weirs, Flumes, Water measurement, Seepage.

Several common flow-measurement devices including the weir, Parshall flume, and scow were used in field studies of infiltration/inflow in Puerto Rico. Mathematical determinations of infiltration/inflow were made by calculating the hydraulic gradient, the height of water in the sewer, and the velocity head loss. Both of these instrumental and physical-mathematical methods for flow determination are reviewed, stressing the advantages and disadvantages of each, their sources of error, and methods used to resolve that error, wherever possible.

77:07B-025
COMPENSATING FOR CONSTRUCTION ERRORS IN CRITICAL-FLOW FLUMES AND BROAD-CRESTED WEIRS,
Replogle, J.A.
United States Department of Agriculture, Agricultural Research Service, United States Water Conservation Laboratory, 4331 East Broadway, Phoenix, Arizona 85040.
Proceedings of the Symposium on Flow Measurement in Open Channels and Closed Conduits, Gaithersburg, Maryland, p 201-218, February 23-25, 1977. 5 fig, 1 tab, 8 ref, 1 equ.

Descriptors: Flow measurement, Flumes, Weirs, Open channel flow, Water measurement.

Critical-flow flumes and broad-crested weirs can now be routinely and accurately calibrated (±2%) by computer techniques over a wide range of flow rates and flume cross sections, including trapezoidal and complex shapes. This ability permits detailed compensation for errors introduced by construction anomalies. Procedures were developed and used on a series of primary devices in irrigation canals, including trapezoidal flumes and broad-crested weirs, which identified construction errors and accurately related a readout mechanism to the primary device, as constructed, so that the original intended accuracy could be restored.

77:07B-026
INSTRUMENT ERRORS IN OPEN CHANNEL FLOW MEASUREMENT SYSTEMS,
Grant, D.M.
Instrumentation Specialties Company, Post Office Box 5437, Lincoln, Nebraska 68505.
Proceedings of the Symposium on Flow Measurement in Open Channels and Closed Conduits, Gaithersburg, Maryland, p 91-103, February 23-25, 1977. 9 ref.

Descriptors: Flow measurement, Open channels, Open channel flow, Instruments.

Certain aspects of open channel flow measurement systems are briefly discussed, including primary and secondary measuring devices. The two functions of a secondary measuring device (open channel flow meter) are discussed: level measurement and level-to-flow rate conversion. Some of the common methodologies used to accomplish each of the two functions of a secondary device are described, and the possible sources and magnitudes of errors associated with each of these methodologies are analyzed. Level measurement methods discussed are: float, electrical, ultrasonic, bubbler, and dipping probe. Level-to-flow rate conversion methods discussed are: mechanical cam, electronic analog function generator, electronic memory device, and opto-electronic function generator. In the interest of promoting a uniformity of specifications, a standard general format for open channel flow meters is proposed.

77:07B-027
NUMERICAL MODELING OF TWO-DIMENSIONAL FLUMES,
Davis, R.W.
Mechanics Division, National Bureau of Standards.
Proceedings of the Symposium on Flow Measurement in Open Channels and Closed Conduits, Gaithersburg, Maryland, p 219-242, February 23-25, 1977. 12 fig, 2 tab, 10 ref, 9 equ.

Descriptors: Water measurement, Flow measurement, Flumes, Open channel flow, Hydraulics, Model studies, Weirs.

Flumes are commonly used devices for the measurement of open-channel flow rates. Their range of operation has been limited, however, because, outside of experimentally calibrating each configuration used, one has had to resort to one-dimensional theory for flow rate determination. This theory is restricted to fairly low values of upstream-head to crest-length ratio, as well as to almost level flumes with a resonably uniform incoming velocity profile and nonconverging sidewalls. The present study is concerned with extending the operational range of a particular type of flume (the two-dimensional version of the Palmer-Bowlus flume) into areas where one-dimensional theory loses its validity. The determination of the head-discharge relationship for this flume is done numerically by use of the SOLA finite difference routine for two-dimensional free-surface flows. Effects of changes in flume geometry, channel slope, and upstream velocity profile are investigated. The numerical results are verified experimentally.

77:07B-028
THE DESIGN OF OPEN CHANNEL ACOUSTIC FLOWMETERS FOR SPECIFIED ACCURACY: SOURCES OF ERROR AND CALIBRATION TEST RESULTS,
Lowell, F.C., Jr.
Ocean Research Equipment, Incorporated, Accusonic Division, Falmouth, Massachusetts 02541.
Proceedings of the Symposium on Flow Measurements in Open Channels and Closed Conduits, Gaithersburg, Maryland, p 243-266, February 23-25, 1977. 16 fig, 6 ref.

Descriptors: Flow measurement, Water measurement, Velocity, Flow rate.

The design of open channel acoustic flowmeters is more difficult than the design of pipeline flowmeters because of errors introduced by the free surface, as well as because the open channel environment is usually more susceptible to attenuation and multipath conditions which can inject large errors unless special signal recognition and filtering techniques are employed. The sources of error in open channel acoustic flowmeters are tabulated and discussed.

77:07B-029
VALIDATION OF USE OF DYE-DILUTION METHOD FOR FLOW MEASUREMENT IN LARGE OPEN AND CLOSED CHANNEL FLOWS,
Morgan, W.H., Kempf, D., and Phillips, R.E.
Peerless Pump, An Indian Head Company, Montebello, California 90640.
Proceedings of the Symposium on Flow Measurement in Open Channels and Closed Conduits, Gaithersburg, Maryland, p 361-394, February 23-25, 1977. 12 fig, 4 tab, 13 ref, 1 append.

Descriptors: Flow measurement, Water measurement, Open channel flow, Pipe flow, Pipelines, Tracers, Flumes, Calibrations.

The use of water soluable tracers for determining flow rates of rivers and streams has been practiced for several decades, both in the United States and abroad. During the last 15 years the economical availability of water soluable dyes, coupled with the considerable technical improvement in fluorometry equipment, has made feasible the use of dye-dilution methods for in situ calibration and other flow measurement devices.

77:07B-030
CALCULATORS IN TIMER-COUNTERS FOR CURRENT METERS,
Kormilo, S.R.
Papuea New Guinea University of Technology, Department of Electrical and Communications Engineering, Lae (New Guinea).
Journal of the Hydraulics Division, American Society of Civil Engineers, Vol. 103, No. HY9, Proceedings Paper 13230, p 1031-1036, September 1977. 2 fig, 1 ref, 2 append.

Descriptors: *Instrumentation, *Current meters, *Equipment, Electronics, Laboratory tests, Flow, Measurement, Time, Timing, Engineering, Electrical engineering, Hydrology.

An accurate, compact, low-cost, calculator-based electronic timer-counter for current meters was constructed and laboratory tested. Electronic calculators often offer an economically attractive alternative to both electromechanical and other forms of electronic counters. The modification of calculators so that they can act as timer-counters was described in general terms. A summary of the results of tests to determine the effect of temperature and voltage variations on the timing accuracy of a prototype electronic timer-counter was given. Laboratory tests also were performed which compared the prototype to two different electromechanical counters in operation. The tests indicated that, with a few minor changes, the electronic timer-counter would provide many advantages over the electromechanical counters.

77:07B-031
A MECHANICALLY CONTROLLED VARIABLE RATE LEACHING DEVICE,
Holmgren, G.G.S., Juve, R.L., and Geschwender, R.C.
National Soil Survey Laboratory, Lincoln, Nebraska 68508.
Soil Science Society of America Journal, Vol. 41, No. 6, p 1207-1208, December 1977. 1 fig, 1 tab.

Descriptors: Leaching, Sampling, Laboratory studies, Cation exchange.

Twenty-four leaching tubes attached to 60-ml plastic syringes are mounted on the periphery of three vertically aligned slotted discs 45 cm in diameter. The plungers are withdrawn at a controlled rate by a variable speed screw jack that separates the two lower discs holding the plungers and syringe barrels, respectively. Leaching time can be varied from 15 min. to 12 hours or more. The final volume of extract is determined by weighing the syringes. Precision of ammonium acetate CEC and extractable cations by this procedure with 2.5 grams of soil and 50-ml extract matches that of a comparable manual method using vacuum extraction with 5 grams of soil and 100 ml of extract. This apparatus has also cut required operator time in half.

77:07B-032
CORRECTION FOR DISSOLVED NITROUS OXIDE IN NITROGEN STUDIES,
Moraghan, J.T., and Buresh, R.
North Dakota State University, Department of Soils, Fargo, North Dakota.
Soil Science Society of America Journal, Vol. 41, No. 6, p 1201-1202, November-December, 1977. 1 fig, 2 tab, 6 ref.

Descriptors: Nitrification, Denitrification, Nitrogen, Temperature, Sampling.

Rapid methods for the accurate determination of N_2O in atmospheres of closed incubation flasks are now available. However, serious errors in measuring total N_2O within a closed system may arise if dissolved N_2O is not considered. Temperature and the ratio of solution volume to atmosphere volume are important factors determining the magnitude of errors resulting from this cause. A simple formula for calculating dissolved N_2O based on solution and atmosphere volumes, the mass of N_2O in the gaseous phase, and published solubility data for N_2O in water is presented. If the chemical composition of the solution phase is likely to influence solubility coefficients, these values can be experimentally determined using a described technique.

77:07B-033
DESIGN AND TEST OF A FIELD SAMPLER FOR AMMONIA VOLATILIZATION,
Kissel, D.E., Brewer, H.L., and Arkin, G.F.
United States Department of Agriculture, Agricultural Research Service, Texas Agricultural Experiment Station, Post Office Box 748, Temple, Texas 76501.
Soil Science Society of America Journal, Vol. 41, No. 6, p 1133-1138, November-December, 1977. 9 fig, 1 tab, 12 ref.

Descriptors: Ammonia, Fertilizers, Data collection, Sampling, Nitrogen, Fertilization.

A system is needed to measure ammonia volatilization from N fertilizer applied under field conditions. This study was undertaken to develop a device for making these measurements and still maintain a field environment. The basic system developed consists of a vacuum pump, a chemical trap to capture ammonia, and the volatilization chamber.

77:07B-034
DENITRIFYING BACTERIA CAN BE ENUMERATED IN NITRITE BROTH,
Volz, M.G.
Connecticut Agricultural Experiment Station, New Haven, Connecticut 06504.
Soil Science Society of America Journal, Vol. 41, No. 3, p 549-551, May-June, 1977. 2 tab, 20 ref.

Descriptors: Denitrification, Bacteria, Nitrites, Laboratory tests.

Denitrifying- and NO_3- reducing bacteria in air dry, moist and organic matter amended Yalesville fsl, lake water, and in both effluent and drainage field soil from a septic tank system were enumerated using Difco nutrient broth, which contained either or both NO_3- and NO_2- and was incubated anaerobically. Most probable numbers (MPN) of denitrifiers were always less than those of NO_3-reducers in the same sample, and constituted from 0.02% to 70% of bacteria capable of aerobic growth on yeast extract agar.

77:07B-035
SAMPLING DISTRIBUTION OF NITRATES IN IRRIGATED FIELDS,
Reuss, J.O., Soltanpour, P.N., and Ludwick, A.E.
Colorado State University, Department of Agronomy, Fort Collins, Colorado 80523.
Agronomy Journal, Vol. 69, No. 4, p 588-592, July-August, 1977. 2 fig, 5 tab, 12 ref, 8 equ.

Descriptors: Sampling, Nitrates, Irrigation, Irrigation effects, Irrigation practices, Colorado, Nebraska, Laboratory tests, Fertilizers, Fertilization.

The object of this study was to determine the components of variability encountered in sampling farmers' fields for soil nitrates. This information is required for formulating recommendations for sampling plan and intensity. Twenty-four irrigated farm fields in northeastern Colorado and Western Nebraska were sampled on 61 x 61 m grids. One soil core was taken in 30-cm increments from each grid to a depth of 120 cm. Duplicate cores were obtained from each third grid to allow determination of within grid variability. The laboratory-induced variability was also estimated. The results indicated that within and among grid standard deviations increased as the means increased. The standard errors of laboratory determinations (subsampling plus analytical errors) also increased as the means increased.

77:07B-036
A PORTABLE CHAMBER FOR RAPID EVAPOTRANSPIRATION MEASUREMENTS ON FIELD PLOTS,
Reicosky, D.C., and Peters, D.B.
South Carolina Agricultural Experiment Station, Florence, South Carolina.
Agronomy Journal, Vol. 69, No. 4, p 729, 732, July-August, 1977. 4 fig, 6 ref.

Descriptors: Sampling, Evapotranspiration, Crop production, Scheduling, Irrigation efficiency, Soil water, Soil moisture, Temperature.

The increased importance of water-use efficiency in agricultural production has prompted the need for new techniques to measure evapotranspiration (ET) on field plots to evaluate the effects of new soil and water management practices of an inexpensive, portable chamber for rapid field measurement of ET. This chamber was constructed from aluminum conduit covered with Mylar film and mounted on a farm tractor for portability. The air within the chamber was mixed constantly with four strategically located fans. The ET rate was calculated from the air and wet-bulb temperatures of a thermistor psychrometer before the chamber was lowered on the plot and 1 minute later. The psychrometer's accuracy was checked by measuring the transpiration from a solution-absorption system that accurately measured the change in solution level using an LVDT-float system. When microlimatological conditions were changing slowly, transpiration was assumed to be equal to the absorption. The high correlation between measured absorption and transpiration rates indicated reasonable accuracy. The chamber's accuracy and rapidity of the measurement, portability, and relatively low cost makes it a useful tool in measuring ET under field conditions.

77:07B-037
DETERMINING CATION EXCHANGE CAPACITY: A NEW PROCEDURE FOR CALCAREOUS AND GYPSIFEROUS SOILS,
Polemio, M., and Rhoades, J.D.
United States Salinity Laboratory, United States Department of Agriculture, Agricultural Research Service, Riverside, California 92502.
Soil Science Society of America Journal, Vol. 41, No. 3, p 524-528, May-June, 1977. 2 fig, 2 tab, 23 ref.

Descriptors: Cation exchange, Soils, Soil tests, Soil investigation, Soil properties.

A new, two-step procedure is presented for determining the cation exchange capacity of calcareous and gypsiferous soils. The method eliminated most of the errors inherent in conventional methods. The cation exchange sites are saturated with sodium by four successive "equilibrations" of the soil (4-5 grams) with 33-ml increments of a pH 8.2, 60% ethanol solution of 0.4N NaO Ac - 0.1N NaCl (saturating solution). The saturated sample then is extracted with three 33-ml increments of 1.0N, pH 7 magnesium nitrate. Total sodium (Nat) and chloride (Clt) are subsequently determined in the extracted solution. Chloride (Clt) is determined so that the soluble sodium (Nasol), from the excess saturating solution carried over from the saturation step to the extraction step, may be deducted from the total sodium (Nat) to obtain exchangeable sodium (Naexch), which is equivalent to the CEC. Thus, CEC = Naexch = (Nat - Nasol) = Nat - (Clt(Na/Cl) saturating solution) where (Na/Cl) saturating solution is the ratio of Na to Cl in the saturating solution.

SECTION XXIV

RESOURCES DATA

EVALUATION, PROCESSING AND PUBLICATION (GROUP 07B)

77:07C-001
PREDICTION OF MINERAL QUALITY OF IRRIGATION RETURN FLOW: VOLUME IV. DATA ANALYSIS UTILITY PROGRAMS,
Bureau of Reclamation, Engineering and Research Center, Denver, Colorado 80225.
Publication No. EPA-600/2-77-179d, August 1977. 222 p, 1 ref.
(See 77:05G-030)

77:07C-002
EXPERIMENTAL EVALUATION OF TWO INFILTRATION EQUATIONS,
Idike, F., Larson, C.L., Slack, D.C., and Young, R.A.
Minnesota University, Department of Agricultural Engineering, Saint Paul, Minnesota.
Presented at the 1977 Winter Meeting of the American Society of Agricultural Engineers, December 13-16, 1977, Palmer House Hotel, Chicago, Illinois, p 1-21. 6 fig, 4 tab, 21 ref, 6 equ.

Descriptors: Infiltration, Soil water, Soil moisture, Soil water movement, Runoff, Equations.

Infiltration from constant application rates as predicted by the Holtan equation and the Mein and Larson equation was compared to values determined experimentally. Both equations did a good job of predicting infiltration during latter and middle portions of the experimental runs. The Mein and Larson equation did a good job of predicting time to start of runoff, while the Holtan equation generally underpredicted infiltration during initial stages of the runs.

ENGINEERING WORKS

STRUCTURES (GROUP 08A)

77:08A-001
A PROPOSED TECHNIQUE FOR TESTING AND EVALUATION OF HARDENED IRRIGATION DITCH CONCRETE,
Hess, J.D.
Darco Engineering International, El Centro, California.
Presented at the 1977 Annual Meeting of the American Society of Agricultural Engineers, June 26-29, 1977, Raleigh, North Carolina, North Carolina State University, p 1-10. 4 fig, 1 tab.

Descriptors: Irrigation, Irrigation systems, Concrete, Sampling, Canals, Canal linings.

A new testing technique is presented for the strength evaluation of hardened irrigation ditch concrete. The test procedure eliminates the need for evaluating in-service strength characteristics based solely upon conventional 6 inch by 12 inch cylinder tests or tests on small cores or prisms. No L/D corrections are required.

SECTION XXVI

ENGINEERING WORKS

HYDRAULICS (GROUP O8B)

77:O8B-001
HYDRAULIC JUMPS AND WAVES AT ABRUPT DROPS,
Rajaratnam, N., and Ortiz, N.V.
Alberta University, Department of Civil Engineering, Edmonton, Alberta, Canada.
Journal of the Hydraulics Division, American Society of Civil Engineers, Vol. 103, No. HY4, Proceedings Paper 12869, p 381-394, April 1977. 14 fig, 2 tab, 11 ref, 2 append.

Descriptors: *Drops (structures), *Flow, *Hydraulic jump, Open channel flow, Open channels, Shear stress, Turbulent flow, Waves (water), Tailwater, Hydraulics.

Experimental results on the structure of the mean flow in B-jumps and waves formed at abrupt drops in open channels for a wide range of the supercritical Froude number and relative drop height were presented. In the B-jump, the supercritical stream undergoes diffusion; firstly as a curved free jet sandwiched between the captive eddy on the bottom and the surface roller on the top, and secondly as a reattached plane wall jet with the surface roller on its top. The bed shear stress in the downstream channel was measured and well correlated along with the variation of the maximum velocity. In the wave, it was found: (1) that the supercritical stream is deflected by the tailwater back-pressure, and (2) that the deflected stream behaves like a curved surface jet until it plunges into the tailwater. The decay of the maximum velocity in the wave was found to be generally faster than that in the classical jump and the B-jump.

77:O8B-002
EFFECT OF BRANCH SPACING ON LOSSES FOR DIVIDING FLOW,
Hecker, G.E., Nystrom, J.B., and Qureshi, N.A.
Worcester Polytechnic Institute, Department of Civil Engineering, Worcester, Massachusetts.
Journal of the Hydraulic Division, American Society of Civil Engineers, Vol. 103, No. HY3, Proceedings Paper 12791, p 265-279, March 1977. 10 fig, 15 ref, 2 append.

Descriptors: *Head loss, *Discharge (water), *Hydraulics, *Pipe flow, *Laboratory tests, Hydraulics, Energy equation, Discharge coefficient, Friction, Dimensional analysis, Equations.

Tests were conducted to evaluate the effects of port spacing on head loss and discharge coefficients for dividing manifold flow. A branch geometry typical of an actual diffuser design was used, and the branch-to-main-pipe-diameter ratio and the relative spacing between branches were varied by increments. Evaluation of the test data for dividing flow indicated that the asymmetry of the velocity distribution in the main pipe downstream of a branch increased with decreasing branch spacing; the form loss coefficient for through-flow in the main pipe increased with decreasing relative branch spacing; and the branch discharge coefficient increased with decreasing relative branch spacing. Although a particular geometry was used in the investigation, basic trends and percentage changes in the coefficients with the branch spacing may be generally applicable.

77:O8B-003
FREE FLOW IMMEDIATELY BELOW SLUICE GATES,
Rajaratnam, N.
Alberta University, Department of Civil Engineering, Edmonton, Alberta, Canada.
Journal of the Hydraulic Division, American Society of Civil Engineers, Vol. 103, No. HY4, Proceedings Paper 12867, p 345-351, April 1977. 7 fig, 1 tab, 9 ref, 2 append.

Descriptors: *Boundary layers, *Flow, *Sluice gate, Gate control, Gates, Open channel flow, Sluices, Hydraulics, Laboratory tests, Channels, Profiles, Pressure.

Based on the results of an experimental study, it was found that the water surface profiles immediately below sluice gates in rectangular channels are similar. The coefficient of contraction was found to be larger than the theoretically predicted value, and it is not possible to attribute this difference to boundary layer effects alone. The pressure field in the converging flow was measured, and the dimensionless excess pressure on the bed was correlated with the dimensionless longitudinal distance from the gate.

77:08B-004
TWO-DIMENSIONAL SEARCHES FOR HIGH-YIELD WELL SITES,
Turk, G.
Ground Water, Vol. 15, No. 4, p 269-275, July-August, 1977. 6 fig, 2 tab, 8 ref.

Descriptors: *Well spacing, *Drilling, *Exploration, Test wells, Costs, Aquifer characteristics, Transmissivity, Optimization, Sampling, Depth, Water yield, Analytical techniques.

In areas where bedrock is irregular, greater saturation thickness of aquifer will associate with the depression in the bedrock formation. Wells located upon the depressions can yield significantly higher amounts of water. Hence, finding the bottom of depression the area will be of interest, and this can be facilitated by drilling test holes. The test holes can be drilled at the nodes of a regular grid; however, more efficient search techniques are available. Fibonacci search in one dimension was proposed recently, and potential saving in drilling cost was demonstrated. But the problem is essentially two-dimensional in nature. This paper described some two-dimensional search procedures and showed that potential saving in drilling cost can be dramatic.

77:08B-005
PROPORTIONAL WEIRS AS VELOCITY CONTROLLING DEVICES,
Rao, L., Rao, N.S., and Chandrasekaran, D.
Indian Institute of Science, Department of Civil Engineering, Bangalore.
Journal of the Hydraulics Division, American Society of Civil Engineers, Vol. 103, No. HY6, Proceedings Paper 13016, p 633-648, June 1977. 5 fig, 2 tab, 10 ref, 2 append.

Descriptors: *Weirs, *Velocity, *Canals, Discharge coefficient, Sedimentation, Sediment control, Orifices, Settling basins, Settling velocity, Hydraulics.

Of the many factors that govern the settling phenomenon, the flow velocity in the settling tanks can be controlled favorably by fixing suitably designed weirs at the outlets of the tanks. The velocity at the bottom should not dislodge the particles that have already settled. The requirements might be met by velocities which are controlled to be constant with respect to the depth of flow, or by velocities which reduce linearly with increasing depth or velocities that vary inversely with the depth. To achieve these types of velocity control, new proportional wiers were designed. Very near to the outlet of the tank, over a small length, the flow was found to be turbulent and noncompliant with the expected type of velocity control. This small length of the disturbance may be provided over and above the theoretical settling length of the tank for efficient sedimentation.

77:08B-006
COMPUTERIZED DESIGN AND ANALYSIS OF SPRINKLER IRRIGATION SYSTEMS,
Hedstrom, W.E., and Bevilacqua, D.P.
Maine University at Orono, Department of Agricultural Engineering, Orono, Maine 04473.
Presented at the 1977 Winter Meeting of the American Society of Agricultural Engineers, December 13-16, 1977, Palmer House Hotel, Chicago, Illinois, p 1-13. 9 ref, 2 equ.

Descriptors: Sprinkler irrigation, Irrigation, Irrigation design, Computer programs, Economics, Hydraulics, Hydraulic design.

The elements of the sprinkler irrigation design procedure which may be computerized are discussed. These include hydraulic analysis, application rate analysis, and an economic analysis as well as other applications. The conditions under which use of the computer is most worthwhile include design of solid-set systems on irregularly-shaped, steep fields.

77:08B-007
PORTABLE, ADJUSTABLE, FLOW-MEASURING FLUME FOR SMALL CANALS,
Replogle, J.A.
Agricultural Research Service, Water Conservation Lab, Phoenix, Arizona.
Transactions of the American Society of Agricultural Engineers, Vol. 20, No. 5, p 928-933, September-October, 1977. 5 fig, 5 ref, 2 append.

Descriptors: *Flumes, *Flow measurement, *Canals, Channels, Instrumentation, Hydraulics, On-site investigations, Measurement, Flow, Design.

A portable, field-site, survey flume was constructed and used to verify placement and design of permanent metering flumes. The portable system consisted of a trapezoidal throat that can be raised and lowered in a flowing field ditch to establish limits of free-flow operation and backwater effects on upstream structures. Mechanical solutions to problems of maintaining gage-zero on a movable-throated flume, stilling-well readout, and movable seals between ditch and flume, were presented. A family of concrete throat sections differing only in height of installation from the canal floor, were recommended for the permanent installations. Flows between about 0.5 cfs (0.01 cu m) and 25 cfs (0.7 cu m) can be measured with the portable system. Satisfactory operation can be achieved with less than 4-in (10-cm) head loss to the canal system. Permanent structures can be installed with high assurance that they will operate as intended, will be convenient enough to be used routinely, and will be rugged enough to remain reliable and accurate, well within the + or - 5% tolerance usually ascribed to field installations.

77:08B-008
EFFECT OF OPENINGS ON INFLOW INTO CORRUGATED DRAINS,
Bravo, N.J., and Schwab, G.O.
Ohio State University, Department of Agricultural Engineering, Columbus, Ohio.
Transactions of the American Society of Agricultural Engineers, Vol. 20, No. 1, p 100-104, January-February, 1977. 6 fig, 3 tab, 11 ref.

Descriptors: *Drains, *Inflow, *Analog models, *Orifices, Plastic pipes, Mathematical models, Saturated flow, Laplaces equation, Boundaries (surfaces), Groundwater potential, Hydraulic conductivity, Flow, Soil water movement.

The relative effectiveness of the openings in corrugated plastic drains as influenced by the presence of soil within the corrugations and within the openings themselves was evaluated from the standpoint of water inflow for saturated conditions in a homogeneous, isotropic soil. Electrical analog models provided empirical estimates of the relative flow into drain openings as well as the boundary conditions for mathematical models. Three-dimensional mathematical models were based on Laplace's equation with appropriate boundary conditions. After agreement between the analog and mathematical models was established for simple configurations, inflow for the more complicated cases was measured with electric analog models.

77:08B-009
SIMULATION OF IMPOUNDMENT TERRACE HYDRAULICS,
Rochester, E.W., and Busch, C.D.
Auburn University, Department of Agricultural Engineering, Auburn, Alabama.
Transactions of the American Society of Agricultural Engineers, Vol. 20, No. 1, p 76-84, January-February, 1977. 5 fig, 8 ref.

Descriptors: *Terracing, *Impoundments, *Model studies, Mathematical models, Inflow, Discharge (water), Depth, Water levels, Computer models, Pipes, Pipe flow, Drainage, Hydraulics, Agriculture, Simulation analysis.

A digital simulation predicts flow conditions associated with a series of two impoundment terraces. The simulation routes inflowing water through the impoundments and associated discharge pipes. Results of the simulation include depths of the water in each impoundment, flow rates through each discharge pipe, and hydraulic head at the junction of the pipes.

77:08B-010
DESIGN OF DRIP IRRIGATION LINES WITH VARYING PIPE SIZES,
Wu, I-P., and Gitlin, H.M.
Hawaii University, Department of Agricultural Engineering, Honolulu, Hawaii.
Journal of the Irrigation and Drainage Division, Vol. 103, No. IR4, p 499-503,
December 1977. 2 fig, 5 ref, 9 equ. 1 append.

Descriptors: Irrigation design, Irrigation efficiency, Hydraulics, Irrigation methods, Hydraulic design, Design, Irrigation engineering.

Most drip irrigation laterals and submains are designed for a single pipe size. The energy gradient line for a lateral with a single size has been derived and presented by an exponential curve that is used as basis for designing laterals or submains of drip irrigation systems on level fields or on slopes. However, under certain field conditions, the length of laterals and submains may be relatively long and have nonuniform slopes. The lateral and submain design may use a series of different pipe sizes. A design technique is presented. The purpose of this paper is to show that by designing laterals or submains with different pipe sizes (different diameters) the energy gradient line will be close to the slope of the lateral or submain; therefore, the pressure variation will be reduced.

77:08B-011
VISCOSITY AND SURFACE TENSION EFFECTS OF WEIR FLOW,
Ranga Raja, K.G., and Lal Asawa, G.
Roorkee University, Department of Civil Engineering, (India).
Journal of Civil Engineers, Vol. 103, No. HY10, p 1227-1231, October 1977. 2 fig,
1 tab, 9 ref, 1 append.

Descriptors: *Weirs, *Discharge measurement, *Discharge coefficient, *Flowmeters, Hydraulics, Water properties, Overflow, Equations, Laboratory tests, Measurement, Viscosity, Surface tension, Analysis, Discharge (water).

Weirs have been in use for a number of decades for the measurement of discharge in channels. The existing discharge relations for weirs predict the discharge reasonably well at high heads; however, the accuracy of these relations is questionable at low heads. This is mainly due to the fact that the effects of viscosity and surface tension of the liquid are important at low heads. Proposed discharge equations for predicting discharge at low heads introduced a correction factor to account for the effects of viscosity and surface tension. The experimentally determined correction factors were presented graphically. In general, the data presented indicated an error of + or - 5% in the prediction of discharge.

77:08B-012
AN INTRODUCTION TO EMISSION UNIFORMITY,
Solomon, K.
Rain Bird Company, 7045 North Grand Avenue, Glendora, California 91740.
Drip/Trickle Irrigation, Vol. 2, No. 1, p 6-10, January-February, 1977. 3 fig.

Descriptors: Irrigation systems, Irrigation engineering, Irrigation design, Hydraulics, Hydraulic design, Irrigation efficiency, Flow rates, Uniform flow, Uniformity coefficient.

There are good reasons to concern ourselves with emission uniformity. The more nearly perfect a system is in terms of emission uniformity, the more it is likely to cost. Various devices, material substitutions and design techniques are available to minimize the problems leading to nonuniformity of emission, but they all cost money and/or time. So the costs of approaching perfection must be weighed carefully against the costs of not achieving it.

77:O8B-013
PIPE SIZES FROM MODIFIED MOODY DIAGRAM,
Debler, W.
Michigan University, Department of Applied Mechanics and Engineering Science, Ann Arbor, Michigan.
Journal of the Hydraulics Division, American Society of Civil Engineers, Vol. 103, No. HY1, p 81-85, January 1977. 1 fig, 2 ref, 20 equ.

Descriptors: Hydraulics, Hydraulic design, Irrigation design, Irrigation engineering, Moody resistance diagram, Pipe flow, Pipes, Pipelines, Dimensional analysis.

In the course of developing some instructional material, a simple procedure evolved to extend the useful information contained on the Moody Diagram. Concurrently, the essence of that work's results was published by Lai and Lee (2). Nevertheless, a different point of view had been adopted in the development which makes the final result useful, especially if one wishes to demonstrate the utility of dimensional analysis.

77:O8B-014
EMITTER SELECTION,
Gladigau, L.
Scientific Irrigation Systems, Department of Civil Engineering.
Drip/Trickle Irrigation, Vol. 2, No. 1, p 11-15, January-February, 1977. 2 fig, 1 tab.

Descriptors: Irrigation engineering, Irrigation systems, Irrigation design, Hydraulics, Hydraulic design, Head loss, Friction, Flow rates.

Initially, emitter selection depends on the soil, plant requirement, emitter discharge, water quality, and terrain of a particular location. Evaluation will also include emitter cost and system risks. Generally, the emitters offering the more desirable features and lower system risks have a higher unit cost. The initial emitter considered will have an influence on the cost of the mainline and filtration system and may need to be reevaluated before a final selection is made.

77:O8B-015
DRIP/TRICKLE PIPE NETWORK DESIGN,
Hamisch, F.
Ag Water, 22008 Riverside, Shafter, California 93263.
Drip/Trickle Irrigation, Vol. 2, No. 1, p 23-26, January-February, 1977. 1 fig, 1 tab.

Descriptors: Irrigation engineering, Irrigation systems, Irrigation design, Hydraulics, Hydraulic design, Irrigation systems, Head loss, Friction, Flow rates.

The piping network is the means for taking water from its source and delivering it to the emitter in adequate amounts and with the appropriate pressure. The design of this system must be made from a sound engineering approach. The total system must be the most cost effective for the particular application. The least initial capital cost frequently is not the least expensive system for the user. The addition of higher pressures and their related annual operating costs may exceed the initial savings of the "least expensive" system in a short time. Power, water, and other costs are rising rapidly, and it is the designer's responsibility to consider the total costs.

77:O8B-016
QUADRANT-PLATE WEIR,
Ramamurthy, A.S., Subramanya, K., and Pani, B.S.
Concordia University, Department of Civil Engineering, Montreal, Canada.
Journal of the Hydraulics Division, American Society of Civil Engineers, Vol. 103, No. HY12, Proceedings Paper 13395, p 1431-1441, December 1977. 9 fig, 3 tab, 8 ref, 2 append.

Descriptors: *Weirs, *Discharge (water), *Flowmeters, *Rating curves, Theoretical analysis, Measurement, Flow, Hydraulics, Laboratory tests, Equations, Data collections, Discharge coefficient.

The simple weir flow equation was integrated numerically for a quadrant plate weir to show that the head-discharge relationship for this weir is approximately linear. Theoretically, deviations from linearity (H vs Q) can be limited to 0.5% by a judicious choice of the parameters that determine the weir geometry. The results of experiments on selected weirs were in agreement with the predicted relationships. The coefficient of discharge for the quadrant-plate weir is a function of the approach channel Froude number. For very low Froude numbers (F less than 0.1), the coefficient of discharge asymptotically approaches a value of 0.61.

SECTION XXXIII

ENGINEERING WORKS

HYDRAULIC MACHINERY (GROUP O8C)

77:O8C-001
PROCEEDINGS OF THE SOLAR IRRIGATION WORKSHOP,
The Energy and Development Administration, Sandia Laboratories, Albuquerque, New Mexico.
Proceedings of the Solar Irrigation Workshop, Albuquerque, New Mexico, p 1-60, July 7-8, 1977.

Descriptors: Energy, Pumps, Pumping plants, Irrigation wells, Irrigation efficiency, Economics, Irrigation systems, Wind velocity.

The Energy and Development Administration Solar Irrigation Workshop held in Albuquerque, New Mexico, July 7, 1977, was structured to be a major vehicle for information dissemination and technology transfer. It covered a wide range of subject matter related to crop irrigation including current hardware, economics, experiments, and international requirements. Speakers represented manufacturers, ranchers, governmental entities, universities and research firms. An anticipated heterogeneous attendee population dictated a format of many brief presentations rather than fewer more detailed discussions. This was done to expose the participants to the various expert speakers and to give them a cursory introduction to their particular expertise. These proceedings reflect the same intent. They consist of one page abstracts for each presentation, a brief biographical sketch of each speaker and sources for further information on each subject. The form and format is somewhat loose, but hopefully justified by our goal to publish prior to the conference. This goal was accomplished and served to provide the workshop participants with valuable information enabling them to assess the speakers' subject matter prior to the presentation.

SECTION XXXIV

MANPOWER, GRANTS, AND FACILITIES

RESEARCH FACILITIES (GROUP 09C)

77:09C-001
RESEARCH AND DEMONSTRATION APPROACH TO DEVELOPMENT OF APPROPRIATE SALINITY CONTROL TECHNOLOGIES FOR GRAND VALLEY,
Skogerboe, G.V., and Walker, W.R.
Colorado State University, Department of Agricultural and Chemical Engineering, Fort Collins, Colorado 80523.
Proceedings of National Conference on Irrigation Return Flow Quality Management, Colorado State University, Fort Collins, Colorado, p 353-359, May 16-19, 1977.
5 fig, 4 ref.

Descriptors: Irrigation, Irrigation practices, Salinity, Seepage, Colorado River, Irrigation systems.

Introduction of channel seepage and irrigation percolation losses into the underlying soils and marine aquifer, and the eventual return of these flows to the Colorado River with their large salt loads, make the Grand Valley in western Colorado one of the more significant salinity sources in the Upper Colorado River Basin. The Grand Valley Salinity Control Demonstration Project was formulated to delineate the magnitude of the water and salt flow components from the irrigation systems to evaluate the effectiveness of various water management technologies in reducing the salt load reaching the Colorado River, and to demonstrate appropriate technologies on farmers' fields.

SECTION XXXV

AUTHOR INDEX

Abernathy, G.H.
77:03F-106

Acharya, H.S.
77:02F-045

Affleck, S.B.
77:05B-016

Aguade, E.
77:04B-006

Aiken, J.D.
77:02F-035

Alberts, E.E.
77:07B-020

Alessi, J.
77:03F-058

Alexander, D.M.
77:04A-026

Alexander, M.
77:02G-159

Alfaro, J.F.
77:02G-058

Allen, J.F.
77:02G-054

Allen, R.G.
77:03F-062

Allen, R.R.
77:03F-020
77:04A-040

Allmaras, R.R.
77:02G-082

Alvarez, E.I.
77:02G-008

Amato, M.
77:02G-161
77:02G-162

Amble, V.N.
77:03F-074

Amemiya, M.
77:03F-051

Amerman, C.R.
77:02G-128

Amoozegar-Fard, A.
77:02G-020

Anderson, J.L.
77:02G-023
77:02G-024

Anderson, K.
77:06E-003

Anderson, R.L.
77:06E-010

Appell, G.
77:07B-022

Ardakani, M.S.
77:02G-068
77:04B-013

Arkin, G.F.
77:07B-033

Aron, G.
77:02G-095
77:04A-022

Arvlanandan, K.
77:07B-012

Ashmead, R.M.
77:05B-023

Asmussen, L.E.
77:05G-002

Atkinson, T.C.
77:02F-030

Au, A.K.
77:02G-067

Avnimelech, Y.
77:02G-134

Axthelm, D.D.
77:02F-042
77:02F-044

Ayars, J.E.
77:05B-013

Ayers, R.S.
77:05C-001

Aylmore, L.A.G.
77:02G-004

Babcock, K.L.
77:02G-084

Babu, D.K.
77:02G-019

Baier, R.W.
77:05B-054

Baird, F.L.
77:02F-043

Baker, D.E.
77:02G-133
77:05B-050

Baker, F.G.
77:02G-174

Baker, J.L.
77:05B-030
77:05G-024

Balek, J.
77:02D-008

Ballaux, J.C.
77:02G-150
77:05B-032

Bar-Yosef, B.
77:03F-004

Barfield, B.J.
77:02D-010
77:02J-015
77:02J-019
77:02J-039
77:03F-096
77:04D-004
77:04D-007

Barker, J.
77:02G-091

Barlow, E.W.R.
77:03F-055

Barlow, T.
77:02J-022

Barnhisel, R.I.
77:02G-121

Barr, D.E.
77:02F-016

Barrett, J.W.H
77:06A-001

Bartlett, R.J.
77:03F-031

Basak, P.
77:02F-050
77:02F-052

Bathchelder, A.R.
77:05B-010

Batu, V.
77:04A-032

Bauer, A.
77:03F-112

Bausch, W.
77:02G-037
77:03F-023
77:04A-004
77:07B-019

Bean, E.L.
77:03F-081

Beasley, D.B.
77:02J-020

Beck, L.A.
77:06E-001

Bedient, P.B.
77:05B-027

Beese, F.
77:02G-003
77:02G-060

Bellis, W.H.
77:05B-021

Belt, G.H.
77:03B-001

Benyamini, Y.
77:02G-050

Benz, L.C.
77:03F-019

Berk, W.J.
77:05B-019

Berndt, H.D.
77:04D-006

Berthouex, P.M.
77:05A-009

Beth, F.
77:04A-028

Bevilacqua, D.P.
77:08B-006

Beyerlein, D.C.
77:02E-003

Bhattacharya, A.K.
77:04B-002

Bhattacharya, R.N.
77:02F-002

Bianchi, W.C.
77:05A-007
77:05B-018

Biggar, J.W.
77:02G-041
77:02G-062
77:02K-005
77:05B-012
77:05G-034

Bingham, F.T.
77:02G-066
77:05B-028

Bird, J.W.
77:06E-013

Birtles, A.B.
77:02F-025

Bishop, A.B.
77:05D-003
77:06A-002

Black, J.H.
77:02F-037
77:04B-007

Blackard, J.
77:02J-023

Blackman, W.C., Jr.
77:05G-021

Blackmer, A.M.
77:02G-165
77:07B-008

Blancher, R.W.
77:02G-069

Bliesner, R.D.
77:05B-003

Bloom, P.R.
77:02G-130
77:02G-131

Bloomfield, R.A.
77:02G-137

Bloomsburg, G.L.
77:02G-137

Boast, C.W.
77:02F-008

Boersmo, L.
77:03F-055

Bollen, W.B.
77:02G-158

Bondurant, J.A.
77:02J-006
77:02J-037
77:04A-042

Bos, M.G.
77:04A-011

Bostock, C.A.
77:04B-004

Boswell, F.C.
77:05B-036

Boulton, N.S.
77:02F-047
77:02F-048

Bouma, J.
77:02G-023
77:02G-024

Bourodimos, E.L.
77:05B-025

Bowen, J.E.
77:03F-130

Bowie, A.J.
77:02J-029

Bowler, D.G.
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Boyd, C.E.
77:07B-004

Boyer, J.S.
77:03F-006

Boysen, S.M.
77:02J-035

Bradford, J.M.
77:04D-001

Brakensiek, D.L.
77:02G-011
77:02G-093
77:02G-138

Brash, D.W.
77:03F-015
77:03F-016

Bravo, N.J.
77:08B-008

Bree, J.
77:02G-087

Brehm, R.D.
77:04D-005

Bremner, J.M.
77:02G-119
77:02G-165
77:07B-008

Bresler, E.
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77:02G-080
77:02G-081

Brewer, H.L.
77:07B-033

Bridges, T.C.
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Broadbent, F.E.
77:02G-040
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77:02G-103
77:02K-005

Brockway, C.E.
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Brosz, D.D.
77:02I-016

Brosz, D.J.
77:03F-077

Broughton, R.S.
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Brown, B.D.
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Brown, J.C.
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Brown, K.W.
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Brown, M.J.
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Brown, R.W.
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Bruce, R.R.
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77:03F-044

Brutsaert, W.
77:02D-001
77:02F-013
77:02G-029

Bubenzer, G.D.
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Buchheim, J.F.
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Buchholz, J.R.
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Bucks, D.A.
77:04A-035
77:05G-035

Bulkley, J.W.
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Burau, R.G.
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77:07B-012

Buresh, R.
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Buresh, R.J.
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Burges, S.J.
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Burt, G.W.
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Burwell, R.E.
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77:07B-020

Busch, C.D.
77:08B-009

Busch, J.R.
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Buzio, C.A.
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Caldwell, A.C.
77:03F-109

Calvert, D.V.
77:05B-041

Cameron, D.R.
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Campbell, M.D.
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Carlile, B.L.
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Carlton, A.B.
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Carmack, W.J.
77:02J-033

Caro, J.H.
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77:05G-023

Carter, D.L.
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77:04A-042

Carter, J.N.
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Cary, J.W.
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Casey, M.R.
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Castro, C.L.
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Celnicker, A.C.
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Cerda, A.
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Chadbourne, B.
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Chan, Y.K.
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77:02F-023

Chandrasekaran, D.
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Chang, A.C.
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Channon, M.C.
77:03C-001

Chapin, R.
77:03F-029

Chaplin, C.
77:02D-010

Chau, W.C.
77:02F-034

Chauhan, H.S.
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Chen, M.
77:05D-004

Cheng, P.
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Chesness, J.L.
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77:03F-086

Chichester, F.W.
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Chidley, T.R.E.
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Chien, S.H.
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Chieng, S-T.
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Childs, S.W.
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Chin Choy, E.W.
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Chopra, M.M.L.
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Chow, T.L.
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Christiansen, J.E.
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Chu, S.T.
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77:02G-125

Clapp, D.W.
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Clark, D.L.
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Clark, R.B.
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Clothier, B.E.
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Cochran, V.L.
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Coelen, S.P.
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Cole, D.W.
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Collis-George, N.
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Colombera, P.M.
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Conklin, L.
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Cooley, R.L.
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Cooper, J.D.
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Corapcioglu, M.Y.
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Couvillon, G.A.
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Cox, W.E.
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Cox, W.J.
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Crawford, N.H.
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Creel, B.J.
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Crow, F.R.
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Cruse, R.M.
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Cumberbatch, E.R.St.J.
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Cutler, J.M.
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Daigger, G.T.
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Daigger, L.A.
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Dalal, R.C.
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Dane, J.H.
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Daniel, W.H.
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Das, D.K.
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Davids, G.
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Davidson, J.M.
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77:05B-001

Davis, D.R.
77:02J-005

Davis, H.H.
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Davis, R.M.
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Davis, R.W.
77:07B-027

Davis, S.
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77:03F-114
77:04B-009

Dawes, W.H.
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Day, J.C.
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Day, P.R.
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De Datta, S.K.
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Debler, W.
77:08B-013

DeBoer, D.W.
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DeJong, J.F.
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Delaney, R.H.
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Deluane, R.D.
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Delwiche, C.C.
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Dennis, C.W.
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Derr, D.
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Deuel, I.E., Jr.
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Deuel, L.E.
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Dhillon, P.
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Dick, W.A.
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Digiano, F.A.
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Dillow, D.W.
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Dines, A.J.
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Dixon, R.M.
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Dobrowolski, F.
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Doering, E.J.
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Donigian, A.S.
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Donigian, A.S., Jr.
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Douglas, L.A.
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Dransfield, A.S.
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Dreizin, Y.C.
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Dronsfield, A.S.
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Duble, R.L.
77:03F-076

Duguid, J.O.
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Duke, H.R.
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Dumenil, L.C.
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Duncan, W.G.
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Earl, K.D.
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Eavis, B.W.
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Eck, H.V.
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Edling, R.J.
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77:04D-007

Edwards, K.W.
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Edwards, R.W.
77:02G-073

Ehrler, W.L.
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Eivazi, F.
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Ekin, L.G.
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El-Ghamry, W.M.
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Elliott, H.A.
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Elliott, L.F.
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Elliott, L.S.
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Elprince, A.M.
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Enfield, C.G.
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England, C.B.
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Engleman, R.L.
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Erbach, D.C.
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Escarzaga, R.
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Estes, R.D.
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Evans, R.G.
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77:05G-013

Falco, J.W.
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Fan, L.T.
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Fangmeier, D.D.
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Fenn, L.B.
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Fenster, C.R.
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Fernando, M.J.
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Fetter, C.W., Jr.
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Fischbach, P.E.
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Fisher, P.D.
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Fiskell, J.P.A.
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Fitzsimmons, D.W.
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Fluhler, H.
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77:04B-013

Fogel, M.
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Follett, R.F.
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Folsom, B.L.
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Ford, W.B.
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Foroud, N.
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Foss, J.E.
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Foster, G.R.
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77:02J-042

Fox, R.L.
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Francis, L.
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Francois, L.E.
77:03C-001

Frank, A.B.
77:03F-034
77:03F-035

Franklin, W.T.
77:03C-002

Fraser, G.O., Jr.
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French, O.F.
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Frenkel, H.
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Frere, M.H.
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Fried, M.
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Frind, E.O.
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Fritton, D.D.
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Fromm, G.A.
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Fryberger, I.S.
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Fryrear, D.W.
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Fuchs, M.
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Fuerstenau, D.W.
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Fukuo, Y.
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Galindo, G.G.
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Gambolati, G.
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Garcia-Miragaya, J.
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Gardner, W.R.
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Garner, M.M.
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Gartner, A.
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Garton, J.E.
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Garvey, P.M.
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Gascho, G.J.
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Gast, R.G.
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Gauden, J.P.
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Gaudu, R.
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Gaum, C.H.
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Gear, R.D.
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Gelhar, L.W.
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Geschwender, R.C.
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Ghaibeh, A. Sh.
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Ghildyal, B.P.
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Ghiorse, W.C.
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Gibbs, M.M.
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Gibson, J.A.
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Gilbert, R.G.
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Giles, J.F.
77:02I-012

Gill, M.A.
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Gilley, J.R.
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77:04B-015

Gilliam, J.W.
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Gilmour, J.T.
77:05C-004

Gisser, M.
77:03F-018

Gitlin, H.M.
77:04A-014
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Gladigau, L.
77:08B-014

Gleaton, J.
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Godden, D.P.
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Goh, K.M.
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77:03F-016

Goldhamer, D.A.
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Gole, C.V.
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Goswami, K.P.
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Grady, C.P.L., Jr.
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Graham, W.G.
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Grant, D.M.
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Green, F.H.W.
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Green, R.E.
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Gregg, P.E.H.
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Gregory, J.M.
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Grenney, W.J.
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Grier, H.E.
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Griffin, R.A.
77:02G-067

Griffith, D.R.
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Grillo, L.
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Grimes, D.W.
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Groenevelt, P.H.
77:02C-001

Groote, S.G.
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Gross, T.A.
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Guitjens, J.C.
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Gupta, G.C.
77:05D-007

Gupta, S.K.
77:02G-041

Gupta, V.
77:02G-009

Gupta, V.K.
77:02F-002

Gurovich, E.
77:02G-108

Guthrie, D.L.
77:07B-024

Gutschick, V.P.
77:03F-131

Haan, C.T.
77:02D-009
77:02J-019
77:03F-096
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77:04D-007

Hachum, A.Y.
77:02G-058

Hadas, A.
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Hagan, R.E.
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Hagan, R.M.
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Hagan, W.R.
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Hahne, H.C.H.
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Haimes, Y.Y.
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Haith, D.A.
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Hakonson, T.E.
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Hallsworth, E.G.
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Halvorson, A.D.
77:07B-006

Hamisch, F.
77:04A-024
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Hamon, W.R.
77:02G-138

Hanks, R.J.
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77:04A-002
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77:05G-006

Hanson, C.L.
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Hargrove, R.
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Hargrove, R.S.
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Hargrove, W.L.
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Harmon, W.C.
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Harper, L.A.
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Harrington, R.A.
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Harris, D.G.
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Harris, J.
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Harris, W.
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Harris, W.S.
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Harter, R.D.
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Hassan, F.A.
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Hassett, J.J.
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Haug, R.M.
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Haupt, H.F.
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Hauser, E.W.
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Hauser, V.L.
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Haverkamp, R.
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Hayes, J.C.
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77:02J-039

Heady, E.O.
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77:03F-053

Healy, M.L.
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Heaney, J.P.
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Hecker, G.E.
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Hedstrom, W.E.
77:08B-006

Heerman, D.F.
77:04A-020

Heermann, D.F.
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77:05B-010

Heft, F.E.
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Heinemann, H.G.
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Helweg, O.J.
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Helyar, K.R.
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Hendershott, C.H.
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Hendrick, J.G.
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Herkelrath, W.N.
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Herrera, I
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Hess, J.D.
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Hess, R.E.
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Hickey, J.J.
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Highfill, R.E.
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Hiler, E.A.
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Hira, G.S.
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Hoa, N.T.
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Hockenbury, M.R.
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Hoffman, D.L.
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Hoffman, G.J.
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77:05B-028

Hogg, H.C.
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Hohn, C.M.
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Holburt, M.B.
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Holmgren, G.G.S.
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Holt, R.F.
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Horner, G.L.
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Hornsby, A.G.
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Horton, M.
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Horton, M.L.
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Hossmer, L.R.
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Howell, T.A.
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Hoyt, G.D.
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Huang, C.P.
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Huber, W.C.
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Huck, M.G.
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Huggins, L.F.
77:02J-020

Hull, J.E.
77:05G-017

Humpherys, A.
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77:03F-116

Hunsaker, V.E.
77:03F-126

Huszar, P.
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Hutka, J.
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Hwang, C.L.
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Hynes, R.
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Idike, F.
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Idso, S.B.
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Irwin, R.W.
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Jackson, D.R.
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Jackson, G.D.
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Jackson, R.D.
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Jackson, R.H.
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Jacob, C.M.
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Jacober, F.C.
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Jacoby, E.L., Jr.
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Jain, J.K.
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Jaiswal, C.S.
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Jat, R.L.
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Jauregui, L.U.
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Jegat, H.
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Jensen, M.E.
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John, P.H.
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Johnson, C.W.
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Johnson, D.W.
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Johnson, H.P.
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77:05G-024

Johnson, R.L.
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Johnston, W.R.
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Johnstone, W.R.
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Jonch-Clausen, T.
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Jones, L.A.
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Jones, M.B.
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Jones, O.R.
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Jones, W.E.
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Judy, C.H.
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Juo, A.S.R.
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Jurinak, J.J.
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Jury, W.A.
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Juve, R.L.
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Kamburov, J.
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Kanchanasut, P.
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Kanemasu, E.T.
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Karmeli, D.
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Kassas, M.
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Katopodes, N.D.
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Kaushik, N.K.
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Kay, B.D.
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Keeney, D.R.
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77:05B-017

Kelly, W.E.
77:02F-036

Kempf, D.
77:07B-029

Kennedy, S.
77:03F-104

Keren, R.
77:02G-121

Kerr, J.P.
77:02G-065

Khalid, R.A.
77:02G-109

Khengre, S.T.
77:02G-146

Kholdebarin, B.
77:05B-051

Kibler, D.F.
77:06D-002

Kiker, C.P.E.
77:06E-006

Kimball, B.A.
77:02G-082

Kimberlin, L.W.
77:02J-026
77:02J-028

King, J.G.
77:03B-001

King, L.G.
77:05B-003

Kinnell, P.I.A.
77:02J-001

Kinney, W.
77:04A-005

Kipp, K.L., Jr.
77:02F-037
77:04B-007

Kirkham, D.
77:02G-139
77:02J-016
77:05B-016

Kirkham, M.B.
77:05B-056

Kishi, Y.
77:02F-028

Kissel, D.E.
77:02G-104
77:05B-043
77:07B-033

Klepper, B.
77:02I-017

Klepper, R.
77:02F-027

Kley, W.
77:05B-022

Klusman, R.W.
77:05A-006

Klute, A.
77:02G-021
77:02G-176

Knowles, R.
77:02G-170

Kodama, M.
77:04A-032

Koelliker, J.K.
77:02G-129

Koeppe, D.E.
77:02I-013

Kohl, D.H.
77:03F-042

Kormilo, S.R.
77:07B-030

Kouwen, N.
77:02E-001

Kovda, V.A.
77:02J-009

Kramer, P.J.
77:02I-001

Krishnamurthi, N.
77:02F-031

Kroontje, W.
77:02G-147
77:02G-171

Krull, D.L.
77:03A-001

Kruse, E.G.
77:02G-141
77:04A-020

Kunkel, R.
77:05G-005

Kuraz, E.V.
77:07B-023

Kurihara, K.
77:02G-148

Laag, A.E.
77:02G-145
77:04B-009

Labadie, J.W.
77:03F-088
77:04A-001

Lacewell, R.D.
77:05C-005

Ladd, J.N.
77:02G-161
77:02G-162

Laflen, J.M.
77:05B-030

Laher, M.
77:02G-134

Laidlaw, I.M.S.
77:07B-001

Lakatos, D.F.
77:02G-095

Lakshminarayana, V.
77:02F-019

Lal Asawa, G.
77:08B-011

Land, L.F.
77:02F-022

Landa, E.R.
77:02G-098

Lansford, R.R.
77:04A-009

Lapping, M.B.
77:03F-017

Larsen, R.
77:03F-118

Larson, C.L.
77:07C-002

Larson, S.P.
77:02F-003
77:02F-029

Larson, W.E.
77:02G-079

Lashkari, R.S.
77:05G-018

Laura, R.D.
77:02G-160

Laverdiere, M.R.
77:02G-172

Law, J.P.
77:05G-172

Law, J.P., Jr.
77:03F-007

Layton, J.J.
77:06A-001

Lazenby, A.
77:03F-014

Lee, P.C.Y.
77:02F-012

Lee, Y.S.
77:03F-031

Lefebre, V.
77:02F-040

Lehmann, E.I.
77:05D-009

Leistra, M.
77:05B-052

Lembke, W.D.
77:05D-001

Lenau, C.W.
77:02F-015

Leonard, R.A.
77:02G-007

Lettenmaier, D.P.
77:02E-006

Levin, M.J.
77:02G-001

Lewis, G.C.
77:03F-062
77:04A-006

Lewis, R.B.
77:02E-004

Liggett, J.A.
77:02F-009

Ligon, J.T.
77:02G-054

Lin, S.H.
77:02F-024
77:02G-124
77:02G-143

Lindeborg, K.H.
77:02J-007

Lindsay, W.L.
77:02G-112

Lloyd, J.W.
77:02F-020

Lobello, A.J.
77:06C-001

Lock, M.A.
77:07B-002

Logan, D.
77:06E-012

Logan, T.J.
77:02B-001
77:02J-030

Loganathan, P.
77:02G-106

Lomen, D.O.
77:02G-049
77:02G-061

Long, R.B.
77:02J-007

Longenbaugh, R.A.
77:02F-031

Loomis, R.S.
77:02I-007

Lowell, F.C., Jr.
77:07B-028

Ludwick, A.E.
77:02I-012
77:05B-055
77:07B-035

Lund, L.J.
77:02G-038
77:02G-168

Lutz, J.A., Jr.
77:02G-147
77:02G-171

Luxmoore, R.J.
77:02G-032

Lynne, G.D.
77:06E-006

Maas, E.V.
77:02I-006

MacIntyre, J.L.
77:02G-041

MacKenzie, A.F.
77:05B-048

Mahannah, C.N.
77:05B-037

Malcolm, H.R., Jr.
77:02J-013

Mallory, R.
77:03F-120
77:03F-122

Mancini, T.R.
77:03F-106

Manges, H.L.
77:04A-037
77:07B-021

Manley, D.W.
77:02G-118

Manley, R.E.
77:02G-142

Mannering, J.V.
77:02J-032

Mansell, R.S.
77:05B-001
77:05B-041

Mantz, P.A.
77:02J-003

Marelli, H.J.
77:02J-044

Marion, G.M.
77:02G-084

Marshall, E.J.P.
77:02G-073

Martens, D.C.
77:05B-007

Martin, J.K.
77:02G-156
77:02G-166

Martin, W.W.
77:03F-078

Martinez, T.
77:02G-144

Matousek, J.
77:07B-023

Mattigod, S.V.
77:02G-107
77:02K-003

Mawdsley, J.A.
77:02D-001

McBride, M.B.
77:02G-130
77:02G-131

McCarthy, R.E.
77:02J-036

McClymont, G.L.
77:02F-021

McDowell, LL.
77:05G-032

McFarlane, J.C.
77:02G-102

McHenry, J.R.
77:05B-033

McLaren, A.D.
77:02G-068

McLean, E.O.
77:02B-001

McMaster, G.M.
77:03F-059
77:04A-006

McNeal, B.L.
77:05G-005

McNeill, E.
77:05A-008

McPherson, H.G.
77:03F-006

McRae, S.G.
77:07B-017

McWhorter, D.B.
77:02F-004
77:05B-013
77:05B-045

Meiri, A.
77:02I-008

Meisinger, J.J.
77:05B-035

Meister, A.D.
77:02J-014

Melamed, D.
77:02G-015
77:05G-006

Melstad, J.D.
77:03F-079

Meneely, J.M.
77:02G-034

Menzel, R.G.
77:02E-004

Mercado, A.
77:02F-049

Mero, T.
77:07B-022

Merrill, G.
77:05G-010

Meyer, F.W.
77:05G-017

Meyer, L.D.
77:02J-025
77:02J-041
77:02J-042
77:02J-044
77:07B-011

Michalson, E.L.
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Miller, A.C., Jr.
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Miller, D.E.
77:03F-048

Miller, E.E.
77:02I-014
77:02I-015

Miller, G.E.
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Miller, J.E.
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Miller, R.D.
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Miller, R.H.
77:02G-167

Miller, R.J.
77:05B-012

Miller, W.W.
77:05B-037

Mills, P.F.
77:03F-038

Mishoe, J.W.
77:03F-064

Mishra, B.K.
77:07B-015

Misra, C.
77:07B-015

Miwa, E.
77:02G-148

Miyamoto, S.
77:05B-040

Mock, J.J.
77:03F-041

Moe, R.C.
77:02J-033

Mohammed, R.A.
77:03F-090

Moldenhauer, W.C.
77:02J-028
77:03F-128

Moline, W.J.
77:03F-127

Monke, E.J.
77:02G-128
77:02J-020
77:02J-044

Moraghan, J.T.
77:05A-002
77:07B-032

Morel-Seytoux, H.J.
77:02B-002

Moreshet, S.
77:02D-002

Morgan, W.D.
77:06E-009

Morgan, W.H.
77:07B-029

Morin, J.
77:02G-050

Morrison, J.
77:03F-024

Mortvedt, J.J.
77:02G-059

Moss, A.J.
77:02J-001

Mostertman, L.J.
77:05G-015

Mualem, Y.
77:02G-074

Mubarak, A.
77:02G-083

Mukhtar, M.
77:05B-009

Mulkey, L.A.
77:02J-031

Mullen, G.J.
77:02G-017
77:02G-031

Mullineux, N.
77:02F-023

Munns, D.N.
77:02G-155

Murphy, L.S.
77:03F-109

Murray, W.A.
77:02F-018

Murty, V.V.N.
77:02F-038
77:02F-050

Musick, J.T.
77:04A-040

Mutchler, C.K.
77:02J-010
77:02J-029

Nakayama, F.S.
77:04A-035
77:05G-035

Narasimhan, T.N.
77:02F-014

Narayanan, R.
77:05D-003
77:06A-002

Navarro, A.
77:02F-039

Neff, R.
77:02G-034

Neibling, W.H.
77:02G-129

Neilsen, G.H.
77:05B-048

Nelson, D.W.
77:02G-173
77:02J-021

Nelson, M.J.
77:03F-119

New, L.
77:03F-113
77:03F-115

Newkirk, H.W.
77:04A-041

Newland, L.W.
77:02F-016

Newman, B.A.
77:04B-001

Nielsen, D.R.
77:02G-017
77:02G-018
77:02G-031
77:02G-062

Nightingale, H.I.
77:05A-007
77:05B-018

Nikolski, Y.N.
77:03F-037

Nishita, H.
77:02G-089

Nix, J.F.
77:02J-018

Nolte, B.H.
77:04D-005

Nor, Y.M.
77:02G-085

Nulsen, R.A.
77:02I-005

Nye, J.R.
77:03F-101

Nyquist, W.E.
77:02G-046

Nystrom, J.B.
77:08B-002

Obbink, J.G.
77:04A-026

O'Connor, G.A.
77:02G-013

Oertli, J.J.
77:05B-051

Ohmes, F.E.
77:02G-129
77:04A-037

Olness, A.
77:05G-033

Olsen, E.C.
77:05C-002

Olsen, R.A.
77:02G-083

Olsen, B.R., Jr.
77:03F-103

Onken, A.B.
77:02G-037
77:02G-097
77:03F-023
77:04A-004
77:05B-042
77:05C-005
77:07B-019

Onstad, C.A.
77:02G-093
77:02J-029
77:02J-041
77:02J-042

Ortiz, N.V.
77:08B-001

Ortolano, L.
77:06A-004

Osborn, G.
77:02G-059

Oster, J.D.
77:02G-044

Otterby, M.A.
77:04A-031

Page, A.L.
77:02G-088
77:02G-168

Palacios, E.V.
77:03F-005

Palkovics, W.E.
77:02G-025

Pallas, J.E., Jr.
77:03F-044

Palmer-Jones, R.W.
77:03F-003

Pani, B.S.
77:08B-016

Papendick, R.I.
77:03F-012
77:03F-048

Parfitt, R.L.
77:02G-132

Parlange, J.Y.
77:02G-019
77:02G-127

Parsons, J.W.
77:02G-161
77:02G-162

Patrick, W.H., Jr.
77:02G-109
77:021-019

Pavlik, O.
77:02D-008

Peaslee, D.E.
77:02G-150

Peck, A.J.
77:02G-032

Peri, G.
77:03F-021
77:03F-060

Perold, R.P.
77:04A-013

Perrens, S.J.
77:02G-035

Perrier, E.R.
77:02J-018
77:07B-009

Peters, D.B.
77:07B-036

Petersen, G.W.
77:02G-025

Philip, J.R.
77:02G-002

Phillips, R.E.
77:07B-029

Pick, T.A.
77:02B-002

Pierre, W.H.
77:02G-053
77:02G-120

Piest, R.F.
77:02J-040
77:02J-043
77:04D-001

Pinder, G.F.
77:05B-008

Pitney, M.
77:03F-082

Pitt, W.A.J., Jr.
77:05G-017

Ploss, L.F.
77:03F-050

Pohoryles, S.
77:03F-018

Polemio, M.
77:07B-037

Poulovassilis, A.
77:02G-030
77:02G-033

Power, J.F.
77:03F-058

Prather, R.J.
77:02G-154

Pratt, P.F.
77:02G-038
77:02G-145
77:02K-005
77:04B-009

Price, E.P.
77:02G-045

Price, J.D.
77:05B-006
77:05B-011

Pruitt, W.O.
77:03C-002
77:05B-012

Pugner, P.E.
77:05D-003

Purtymun, W.D.
77:05B-005

Putkey, T.A.
77:02F-041

Qureshi, N.A.
77:08B-002

Raats, P.A.C
77:02G-026

Racotch, A.
77:02J-002

Radosevich, G.E.
77:06E-011
77:06E-005
77:06E-004
77:06A-004

Rains, D.W.
77:02I-007

Rajapopalan, S.P.
77:02F-019

Rajaratnam, N.
77:08B-001
77:08B-003

Ramamurthy, A.S.
77:08B-016

Raney, R.J.
77:02D-005

Ranga Raja, K.G.
77:08B-011

Rango, A.
77:02G-034

Rao, L.
77:08B-005

Rao, N.S.
77:08B-005

Rao, P.S.C.
77:02G-022
77:02I-003

Rauch, H.W.
77:02K-002

Rausch, D.L.
77:05G-031
77:05G-032
77:05G-033

Ravelo, C.J.
77:04A-039

Ravina, I.
77:02G-108

Rawlins, S.L.
77:04A-027

Rawls, W.J.
77:02G-138

Reddy, C.N.
77:02I-019

Reddy, G.Y.
77:02B-001

Ree, W.O.
77:02E-005
77:03F-089

Reed, J.R.
77:02F-023

Reeves, M.J.
77:02F-025

Reginato, R.J.
77:02L-001
77:03F-054

Reichman, G.A.
77:03F-019

Reicosky, D.C.
77:07B-036

Reisenauer, H.M.
77:03F-032

Remson, I.
77:04B-006

Rennes, A.
77:02G-071

Replogle, J.A.
77:08B-007
77:07B-025

Reule, C.A.
77:07B-006

Reuss, J.O.
77:02I-012
77:05B-055
77:07B-035

Rhoades, D.L.
77:05G-016

Rhoades, J.D.
77:05G-001
77:07B-037
77:07B-006

Ribbens, R.W.
77:05G-008

Rich, C.I.
77:05B-007

Richey, C.B.
77:03F-087

Richter, W.
77:02G-060

Rickman, R.W.
77:02G-082

Ritchie, J.C.
77:05B-033

Robinson, W.H., Jr.
77:05A-001

Robinson, J.B.
77:05B-053

Rochester, E.W.
08B-009

Rodgers, N.
77:03F-097

Rodriguez, R.
77:03F-094

Roefs, T.G.
77:04B-004

Rogers, J.S.
77:05B-041

Rogers, R.D.
77:02G-090

Rogowski, A.S.
77:02D-003

Rolfe, P.F.
77:02G-004

Rolston, D.E.
77:02G-039
77:02G-103
77:02G-135
77:07B-016

Romkens, M.J.M.
77:02G-173
77:02G-021

Rosenburg, N.J.
77:03F-040

Rosensheim, J.S.
77:05E-001

Rosenthal, W.D.
77:02D-005

Ross, J.D.
77:02E-004

Ross, R.
77:03F-009
77:05B-044
77:05G-037

Ross, W.D.
77:02G-100

Roth, C.B.
77:02G-173
77:02J-021

Rouse, W.R.
77:03F-038

Routson, R.C.
77:05C-003

Royer, J.M.
77:02G-047

Rubin, H.
77:02F-007

Ruen, J.
77:03F-117

Rushton, K.R.
77:02F-001
77:02F-026

Russo, D.
77:02G-080
77:02G-081

Rutherford, T.
77:02G-089

Sabey, M.B.
77:06E-011

Saffigna, P.G.
77:03F-045
77:03F-056
77:05B-002
77:05B-017

Sagar, B.
77:02F-046

Sagi, R.
77:02J-002

Sahrawat, K.L.
77:02G-163

Sain, P.
77:02G-099
77:05B-053

Sammis, T.W.
77:04A-008

Sandhu, B.S.
77:02I-010
77:02I-011

Sandia Laboratories
77:08C-001

Sandoval, F.M.
77:03F-111

Sangi, A.K.
77:02F-027

Savant, N.K.
77:02G-146

Sawhney, B.L.
77:04B-014

Saxton, K.E.
77:03F-027
77:05B-004

Say, E.W.
77:06A-005

Scharplax, J.D.
77:07B-021

Scherer, C.R.
77:05G-003

Schleicher, J.
77:03F-071
77:03F-121

Schmidt, K.D.
77:05B-020

Schmugge, T.J.
77:02G-034

Schneider, A.D.
77:05B-034

Schreiber, J.D.
77:05G-031
77:05G-032

Schuman, G.E.
77:02J-046
77:05B-004
77:07B-020

Schwab, G.O.
77:04D-005
77:08B-008

Schwartz, F.W.
77:02F-021
77:02F-033

Scott, V.H.
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Scotter, C.N.G.
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Scotter, D.R.
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Selim, H.M.
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Sepaskhah, A.R.
77:02I-009

Shaffer, M.J.
77:05G-008
77:05G-019

Shahane, A.N.
77:03F-072

Shalhevet, J.
77:02I-008

Sharma, R.B.
77:02I-002

Sharma, T.C.
77:04D-003

Sharpley, A.N.
77:05A-003

Sheahan, N.T.
77:04B-011

Shearer, G.
77:02G-113

Shearer, M.N.
77:03F-030
77:04A-036

Shelton, C.H.
77:02J-017

Sheridan, J.M.
77:05G-002

Shih, S.F.
77:03F-064

Shoji, K.
77:03F-067

Shrader, W.D.
77:05B-030

Shuford, J.W.
77:05B-050

Shuman, L.M.
77:02G-086

Siebert, J.E.
77:07B-005

Silberman, E.
77:06B-001

Simmons, C.S.
77:02G-041

Simpson, E.S.
77:04B-004

Sims, J.R.
77:03F-043

Sinai, G.
77:02G-115

Singer, M.J.
77:02J-023

Singh, N.T.
77:02G-151

Singh, S.R.
77:02F-011
77:02F-046
77:02G-051

Singh, U.P.
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Sinha, B.K.
77:02G-051

Sionit, N.
77:02I-001

Sisson, J.B.
77:04A-003

Sitar, N.
77:04B-006

Skaggs, R.W.
77:02G-116
77:02G-126
77:03F-049
77:04A-025

Skogerboe, G.V.
77:03F-057
77:05A-005
77:05B-013
77:05G-013
77:05G-014
77:05G-022
77:06E-005
77:07C-001

Slabbers, P.J.
77:02D-006

Slack, D.C.
77:02D-009
77:02G-123
77:07C-002

Sloneker, L.L.
77:03F-128

Small, L.
77:03F-026

Smallwood, C., Jr.
77:02J-013

Smart, P.L.
77:07B-001

Smeck, N.E.
77:05B-049

Smika, D.E.
77:05B-010

Smith, J.H.
77:02J-005

Smith, J.L.
77:05B-045

Smith, J.P.
77:02J-011

Smith, R.E.
77:02G-127

Smith, S.J.
77:02G-104
77:02G-114

Smith, S.W.
77:03F-057
77:05A-005
77:05G-013

Solomon, K.
77:04A-032
77:04A-034
77:08B-012

Solomon, S.I.
77:02E-001

Soltanpour, P.N.
77:05B-055
77:07B-035

Sommerfeldt, T.G.
77:05G-036

Sorenson, R.E.
77:03F-129

Spaulding, B.W.
77:03F-053

Spencer, J.
77:05A-004
77:05G-011
77:05G-012

Splinter, W.E.
77:02D-011

Spomer, R.G.
77:02J-043
77:02J-046

Sposito, G.
77:02F-002
77:02G-009
77:02G-052
77:02G-107
77:02K-003

Stammers, W.N.
77:05B-053

Stanford, G.
77:05B-035

Stanhill, G.
77:02D-002

Stansell, J.R.
77:03F-044

Starr, J.L.
77:02G-063

Steenhuis, T.S.
77:02G-140
77:03F-066

Stegman, E.C.
77:03F-112

Stephenson, R.L.
77:05A-010

Stevenson, K.R.
77:02I-005

Steward, R.B.
77:03F-038

Stewart, B.A.
77:05G-023
77:05G-040

Stewart, E.H.
77:05B-041

Stewart, J.I.
77:03C-002

Stivers, R.K.
77:02G-046

Stolzy, J.L.
77:02G-032

Stolzy, L.H.
77:02G-010
77:04B-013

Stone, J.F.
77:03F-039

Stone, L.R.
77:02D-005
77:05G-039

Strelkoff, T.
77:04A-017
77:04A-018
77:04A-019
77:05B-047

Streltsova, T.D.
77:02F-047
77:02F-048

Su, Y.S.
77:05D-008

Suarez, D.L.
77:02G-064
77:02K-001
77:05G-016
77:05G-001

Subramanya, K.
77:08B-016

Sullivan, P.
77:02G-009

Sullivan, T.E.
77:03F-126

Sunada, D.K.
77:02F-031

Sunderman, H.D.
77:02G-097
77:07B-013

Swartzendruber, D.
77:02G-046

Swenson, R.S.
77:04A-010

Swoboda, A.R.
77:02G-036
77:05G-026

Syers, J.K.
77:02G-071
77:05A-003

Symeonides, C.
77:07B-017

Szuszkiewicz, T.E.
77:04B-013

Tabatabai, M.A.
77:02G-085
77:02G-149
77:02G-164
77:07B-018

Tandy, D.F.
77:06D-002

Tang, Y.K.
77:02G-116
77:04A-025

Tanji, K.K.
77:02G-041
77:04A-005
77:05B-012
77:05B-038
77:05G-034

Tanner, C.B.
77:03F-056
77:05B-002
77:05B-024

Terman, G.L.
77:02G-057
77:03F-047

The Task Committee
77:04A-012
77:05B-046

Theis, T.L.
77:05D-006

Thirriot, C.
77:02G-094

Thomas, A.W.
77:02G-007
77:02G-141

Thomas, G.W.
77:05B-039

Thorvig, L.
77:02G-098

Thurtell, G.W.
77:02I-005

Tiedje, J.M.
77:02J-024

Tillman, R.W.
77:02G-071
77:05A-003

Timmons, D.R.
77:02J-008

Tiwari, S.C.
77:05D-007

Tofflemire, T.J.
77:05D-004

Tolba, M.K.
77:05G-025

Tollner, E.W.
77:02J-039
77:04D-004

Tomlinson, L.M.
77:02F-026

Touma, J.
77:02G-027

Towle, C.L., Jr.
77:04B-008

Toy, D.W.
77:02G-039

Trava, J.
77:03F-088

Trescott, P.C.
77:02F-003
77:02F-029

Tromble, J.M.
77:02D-007

Trotter, R.J.
77:06D-002

Trouse, A.C., Jr.
77:02G-136

Trout, T.J.
77:05B-045

Tubbs, L.J.
77:05B-029

Tucker, B.B.
77:03F-109

Turk, G.
77:08B-004

Turner, F.C.
77:05B-006
77:05B-011

Tyler, D.D.
77:05B-039

Unger, P.W.
77:03F-036

Unger, S.G.
77:02G-153

Vachaud, G.
77:02G-027
77:02G-047
77:02G-077

Vachirakornwatana, C.
77:04D-004

Van De Pol, R.M.
77:02G-018
77:05B-038

Van Der Ploeg, R.R.
77:02G-003
77:02G-060

Van Genuchten, M.T.
77:02G-012
77:02G-013
77:05B-008

Van Schilfgaarde, J.
77:02G-042

Vanderberg, A.
77:02F-051

Vauclin, M.
77:02G-027

Veith, J.A.
77:02G-052

Verma, S.B.
77:03F-040

Verstraete, W.
77:02G-157

Vieth, G.R.
77:03F-001

Vincenty, C.
77:07B-024

Vlachos, E.
77:06A-001

Vlek, P.L.G.
77:02G-112

Voets, J.P.
77:02G-157

Volz, M.G.
77:02G-063
77:02G-105
77:07B-034

Von Bernuth, R.D.
77:04A-033

Voorhees, W.B.
77:03F-110

Vredenburg, R.T.
77:02G-005

Wade, P.M.
77:02G-073

Wade, J.C.
77:02J-045

Wagenet, R.J.
77:02G-062
77:02G-078
77:02J-038

Wagner, T.P.
77:06A-004

Waldron, L.G.
77:02G-070

Wali, M.K.
77:02I-018

Walker, P.H.
77:02J-001

Walker, P.N.
77:03F-065
77:05D-001

Walker, T.W.
77:03F-015

Walker, W.R.
77:03F-057
77:05A-005
77:05G-007
77:05G-009
77:05G-013
77:05G-014
77:06A-006
77:06E-007
77:07B-010
77:09C-001

Walsh, L.M.
77:03F-108

Walter, M.F.
77:02G-140
77:03F-066

Wang, J.-K.
77:03F-002

Ward, A.D.
77:02J-019

Warneke, J.E.
77:02G-168

Warrick, A.W.
77:02G-017
77:02G-020
77:02G-031
77:02G-043
77:02G-049
77:02G-061

Washington, D.R.
77:07B-024

Watson, K.K.
77:02G-035

Watts, D.G.
77:04B-015

Weaver, R.M.
77:02G-172

Weed, S.B.
77:03F-049

Weisz, R.N.
77:04B-008

Wells, B.R.
77:05C-004

Wells, L.G.
77:02D-009
77:02G-126

Welsh, G.
77:03F-098

Wendt, C.W.
77:02G-037
77:03F-023
77:04A-004
77:05B-042
77:05C-005
77:07B-019

Wengert, N.I.
77:06E-010

Werner, D.
77:05B-022

Westerdahl, L.E.
77:02J-018

Westermann, D.T.
77:05B-035

Westfall, D.G.
77:05B-006

Wheeler, W.B.
77:05B-041

White, A.W., Jr.
77:05G-002

White, E.L.
77:04A-022
77:06D-002

White, G.M.
77:02D-010

White, I.
77:02G-002

White, J.
77:03F-124

White, W.B.
77:02K-002

Whiteley, H.R.
77:05B-053

Whitlock, W.W., Jr.
77:05B-031

Whitmore, J.C.
77:02G-078

Wiebe, H.H.
77:02G-091

Wierenga, P.J.
77:02G-005
77:02G-012
77:02G-013
77:02G-018
77:02G-027
77:02G-077
77:02G-175
77:04A-003
77:04A-029

Wiersma, J.L.
77:02I-016

Wiese, A.F.
77:04A-040
77:05B-034

Wiese, R.A.
77:03F-109
77:03F-129

Wilding, L.P.
77:05B-049

Wildung, R.E.
77:05C-003

Wilke, O.C.
77:02G-037
77:03F-023
77:04A-004
77:05B-042
77:05C-005
77:07B-019

Wilkinson, J.F.
77:02G-167

Willardson, L.S.
77:02G-015
77:04A-002
77:05B-003
77:05C-002
77:05G-006

Williams, J.R.
77:04C-006

Williams, W.A.
77:05B-014
77:07B-003

Willis, R.
77:04B-001

Willis, W.O.
77:02G-005
77:03F-034
77:03F-035

Willis, C.G.
77:05G-021

Wilson, D.O.
77:02G-169

Wilson, G.C.
77:02G-144

Wilson, T.V.
77:02G-054

Wimberly, F.L.
77:02E-005

Wischmeier, W.H.
77:05G-023

Wischmeir, W.H.
77:05G-040

Witherspoon, P.A.
77:02F-014

Wolman, M.G.
77:02J-004

Wood, J.D.
77:02G-044

Woolhiser, D.A.
77:05G-023
77:05G-040

Worthington, P.F.
77:02F-005

Wright, J.L.
77:03F-042

Wright, M.E.
77:05A-001

Wu, I.
77:04A-014

Wu, I.-P.
77:08B-010

Yare, B.S.
77:05B-019

Yates, R.
77:04B-010

Yoshinari, T.
77:02G-170

Young, E.G.
77:02G-048

Young, H.Y.
77:05B-009

Young, J.L.
77:03F-055

Young, L.B.
77:02G-114

Young, R.A.
77:02J-010
77:07C-002

Yu, K.Y.
77:05A-009

Zantua, M.I.
77:02G-119

Zaslavsky, D.
77:02G-115

Ziemnicki, S.
77:02J-040

Zimmerman, D.C.
77:03F-058

Zubriski, J.C.
77:03F-109

SECTION XXXVI

SUBJECT INDEX

Abatement
77:05D-009

Absorption
77:02I-002
77:03F-032
77:05B-054
77:05B-056

Acids
77:05A-010

Activated Sludge
77:05D-002

Administrative Agencies
77:05G-021

Adsorption
77:02G-012
77:02G-013
77:02G-018
77:02G-021
77:02G-022
77:02G-052
77:02G-066
77:02G-067
77:02G-068
77:02G-086
77:02G-101
77:02G-106
77:02G-111
77:02G-121
77:02G-124
77:02G-130
77:02G-132
77:02G-133
77:02G-143
77:02G-147
77:02G-151
77:02G-154
77:02G-172
77:05B-001
77:05B-007
77:05B-023
77:05B-052
77:05B-054
77:05D-004
77:05D-005

Aeration
77:05D-002

Agricultural Activities
77:03F-007

Agricultural Chemicals
77:02E-004
77:05B-006
77:05B-009
77:05G-002
77:05G-004
77:05G-023

Agricultural Runoff
77:02E-004
77:05B-048
77:05B-049
77:05D-001
77:05G-004

Agricultural Watersheds
77:02E-004
77:04D-003
77:05B-004
77:05B-048
77:05B-049
77:05G-002
77:05G-033

Agriculture
77:02D-009
77:02F-032
77:02G-005
77:02G-006
77:02G-018
77:02G-022
77:02G-026
77:02G-034
77:02G-042
77:02G-045
77:02G-050
77:02G-060
77:02G-073
77:02G-118
77:02G-153
77:02I-006
77:02I-007
77:02J-014
77:02J-017
77:02J-026
77:02J-030
77:02J-033
77:02J-043
77:02J-044
77:02J-045
77:03F-001
77:03F-017
77:03F-018
77:03F-020
77:03F-024
77:03F-026
77:03F-027
77:03F-048
77:03F-049
77:03F-051
77:03F-052
77:03F-053
77:03F-058
77:03F-061
77:03F-135
77:04D-005
77:05A-004
77:05B-017
77:05B-046
77:05C-001
77:05G-003
77:05G-012
77:05G-016
77:05G-018
77:05G-020
77:05G-022
77:05G-038
77:06A-003
77:06D-001
77:06E-003
77:06E-004
77:06E-005
77:06E-010
77:06E-011
77:06E-012
77:06E-014
77:08B-009

Agronomy
77:05B-006
77:05B-009

Air Pollution
77:05A-002

Air temperature
77:02G-007
77:02L-001

Aircraft
77:02G-034

Alfalfa
77:02G-070
77:02G-102
77:02G-144
77:03F-019
77:03F-085
77:03F-126
77:04A-008
77:04A-030
77:04A-031
77:04D-005
77:05B-003

Algae
77:05D-008

- Algorithms
  - 77:04A-001
  - 77:04B-001
- Alkaline Soils
  - 77:02G-164
- Alkalinity
  - 77:02F-030
- Alluvial Aquifers
  - 77:05B-005
  - 77:05B-020
  - 77:05B-021
- Alluvial Fans
  - 77:02F-028
- Alluvium
  - 77:05B-021
- Alternative Planning
  - 77:04A-022
- Alternative Practices
  - 77:05G-024
- Aluminum
  - 77:02G-130
  - 77:02G-131
- Amino Acids
  - 77:05A-010
  - 77:07B-001
- Ammonia
  - 77:02G-146
  - 77:02G-152
  - 77:05A-010
  - 77:05B-025
  - 77:05B-036
  - 77:05D-005
  - 77:05D-007
  - 77:07B-033
- Ammonification
  - 77:02G-160
- Ammonium Compounds
  - 77:02G-068
  - 77:05A-010
  - 77:05B-051
- Ammonium Salts
  - 77:05B-043
- Analog Models
  - 77:08B-008
- Analysis
  - 77:02D-001
  - 77:02F-002
  - 77:02F-017
  - 77:02G-033
  - 77:02J-041
  - 77:05B-050
  - 77:08B-011
- Analytical Techniques
  - 77:02D-001
  - 77:02F-002
  - 77:02F-012
  - 77:02F-016
  - 77:02F-026
  - 77:02F-052
  - 77:02G-001
  - 77:02G-005
  - 77:02G-008
  - 77:02G-021
  - 77:02G-047
  - 77:02G-056
  - 77:02G-078
  - 77:02G-083
  - 77:02G-125
  - 77:02G-128
  - 77:02G-175
  - 77:05A-003
  - 77:05A-009
  - 77:05A-010
  - 77:05B-006
  - 77:05B-008
  - 77:05B-009
  - 77:05B-048
  - 77:05B-049
  - 77:05B-050
  - 77:05D-004
  - 77:08B-004
- Animal Wastes
  - 77:02G-145
- Anion Exchange
  - 77:02G-098
- Anions
  - 77:02G-052
  - 77:02G-057
  - 77:02G-101
  - 77:02G-111
  - 77:05B-042
- Anisotropy
  - 77:02F-019
- Annual
  - 77:04B-004
- Antecedent Precipitation
  - 77:02G-034
- Apples
  - 77:04A-026
- Application Methods
  - 77:02I-016
  - 77:05A-010
  - 77:06A-006
  - 77:06D-002
- Appropriation
  - 77:06E-013
- Aqueous Solutions
  - 77:02G-001
  - 77:03B-001
  - 77:05A-009
  - 77:05B-016
- Aquicludes
  - 77:02F-037
- Aquifer Characteristics
  - 77:02F-003
  - 77:02F-010
  - 77:02F-023
  - 77:02F-029
  - 77:02F-039
  - 77:02F-040
  - 77:02F-046
  - 77:02F-047
  - 77:02F-048
  - 77:04B-007
  - 77:05E-001
  - 77:08B-004
- Aquifer Management
  - 77:04B-010
- Aquifer Systems
  - 77:02F-022
  - 77:04B-010
  - 77:06A-006
- Aquifer Testing
  - 77:02F-001
  - 77:02F-006
  - 77:02F-037
  - 77:04B-007
  - 77:04B-010
  - 77:05B-018
- Aquifers
  - 77:02F-001
  - 77:02F-004
  - 77:02F-005
  - 77:02F-006
  - 77:02F-007
  - 77:02F-011
  - 77:02F-013
  - 77:02F-015
  - 77:02F-017
  - 77:02F-019
  - 77:02F-020
  - 77:02F-021
  - 77:02F-023
  - 77:02F-025
  - 77:02F-026
  - 77:02F-027
  - 77:02F-036
  - 77:02F-037
  - 77:02F-038
  - 77:02F-039
  - 77:02F-041
  - 77:02F-046
  - 77:02F-049
  - 77:02F-050
  - 77:02F-051
  - 77:04A-001
  - 77:04B-001
  - 77:04B-004
  - 77:04B-006
  - 77:04B-008
  - 77:04B-010
  - 77:04B-011

77:04B-012
77:05B-005
77:05B-018
77:05B-019
77:05B-022
77:05B-034
77:05E-001
77:05G-017
77:07B-002

Aquitards
77:02F-037

Arid Climates
77:02D-006
77:05G-026

Arid Lands
77:03C-001
77:05G-026
77:06D-001

Arizona
77:02G-042
77:02J-015
77:02K-001
77:03A-001
77:03F-070
77:03F-125
77:04A-030

Arkansas
77:02J-018
77:05C-004

Arsenic
77:02G-069

Artesian Aquifers
77:02F-040

Artesian Heads
77:02F-015

Artificial Recharge
77:04B-011
77:05A-007
77:05B-018

Asphalt
77:05G-036

Atlantic Coastal Plain
77:05B-019

Atmosphere
77:02D-001
77:02F-030

Automatic Control
77:03F-104

Automation
77:03F-030
77:03F-104
77:03F-123
77:03F-125
77:04A-038
77:07B-005

Backwater
77:02E-001

Bacteria
77:02G-105
77:05D-002
77:07B-034

Barley
77:02G-070
77:05B-056

Base Flow
77:02F-018
77:02G-025
77:05B-021

Beans
77:04A-006
77:05B-01[illegible]

Bed Load
77:02J-001
77:02J-002
77:02J-003
77:02J-011

Beds
77:02J-002

Behavior
77:04B-012

Beneficial Use
77:06E-013

Benefits
77:03F-005
77:04A-022

Bibliographies
77:04A-012

Bicarbonates
77:05B-005

Biochemical Oxygen Demand
77:05G-018

Biological Treatment
77:05D-008

Biomass
77:02I-018

Bluegrasses
77:03F-012

Border Irrigation
77:04A-017
77:04A-018
77:04A-019

Borehole Geophysics
77:02F-021

Boron
77:02G-154
77:03F-130

Bottom Sediments
77:05G-033

Boundaries (Surfaces)
77:02F-004
77:02F-008
77:02F-009
77:02F-028
77:08B-008

Boundary Layers
77:02D-001
77:02F-010
77:08B-003

Bromides
77:05B-002
77:05B-042

Brucine Method
77:05A-009

Bulk Density
77:02G-079
77:02G-082
77:02G-151
77:02G-168
77:02J-010
77:03F-110
77:07B-023

Cadmium
77:02G-088
77:02I-013
77:02I-019
77:05A-006
77:05B-056
77:05D-005
77:07B-017

Cadmium Uptake
77:05B-056

Calcareous Soils
77:02G-161
77:02G-162
77:02K-001
77:05B-040
77:05B-043

Calcite
77:02F-030
77:02K-001
77:02K-002

Calcium
77:02F-016
77:02F-030
77:02G-064
77:02G-066
77:02G-080
77:02G-081
77:02G-106

77:02G-107
77:02G-108
77:02G-155
77:02J-008
77:03F-032
77:04B-009
77:05B-005
77:05B-049
77:05D-006

Calcium Carbonate
77:02G-100
77:02K-001
77:05G-001

Calcium Chloride
77:02G-004
77:02G-077

Calibrations
77:02G-047
77:05A-001
77:07B-029

California
77:02F-013
77:02G-038
77:02G-045
77:03F-120
77:04B-011
77:05A-007
77:05B-014
77:05B-018
77:05B-020
77:05B-051
77:05G-010
77:06E-002
77:07B-003

Canada
77:02F-021
77:05B-048

Canal Design
77:03F-002

Canal Linings
77:05G-013
77:05G-014
77:08A-001

Canal Seepage
77:03F-063
77:03F-095

Canals
77:02G-048
77:03F-005
77:08A-001
77:08B-005
77:08B-007

Canopy
77:02L-001

Capillary Action
77:02F-031

Capillary Conductivity
77:02G-011
77:02G-029

Capillary Water
77:02G-011
77:02G-033
77:02G-141

Carbon
77:02G-156
77:02G-166
77:07B-014

Carbonate Dioxide
77:02F-030
77:02K-002

Carbonate Rocks
77:02K-002

Carbonates
77:02G-084
77:05B-005

Carrots
77:03F-079

Cation Exchange
77:02G-064
77:02G-066
77:02G-068
77:02G-082
77:02G-088
77:02G-107
77:02G-108
77:02G-119
77:02G-121
77:02G-155
77:05B-033
77:05G-034
77:07B-012
77:07B-031
77:07B-037

Cations
77:02F-016
77:02G-004
77:02G-057
77:02G-106
77:02G-107
77:02G-108
77:03F-032
77:04B-009

Caves
77:02F-030
77:02K-002

Cements
77:02G-046

Center Pivot Systems
77:04B-015

Central United States
77:02G-034

Centrifugation
77:02G-083

Cesium
77:02G-004
77:05B-007

Channel Erosion
77:02J-043
77:04A-015

Channel Flow
77:02E-005
77:02G-142
77:04A-015

Channel Improvement
77:04A-015

Channels
77:02F-011
77:02J-013
77:04A-015
77:08B-003
77:08B-007

Chelation
77:02J-024

Chemical Analysis
77:02G-173
77:05A-009
77:05G-033

Chemical Oxygen Demand
77:02J-008

Chemical Potential
77:05A-009

Chemical Precipitation
77:02G-015
77:02K-001
77:05B-001
77:05B-023

Chemical Properties
77:02G-047
77:02G-173
77:05A-009
77:05B-007
77:05G-033

Chemical Reactions
77:02K-005
77:05A-002
77:05E-002

Chemicals
77:02E-004
77:02F-049
77:03F-133
77:05A-002
77:05A-007
77:05B-005

Chemistry
77:02F-030
77:02G-004
77:02G-083
77:02G-173
77:02K-002
77:05B-023

Chiselling
77:02G-082

Chlorides
77:02F-016
77:02G-004
77:02G-018
77:02G-023
77:02G-024
77:03F-045
77:03F-056
77:05B-002
77:05B-005
77:05B-015
77:05B-017
77:05B-039
77:05B-050

Clay Loam
77:02G-010
77:02G-012
77:02G-013
77:02G-017
77:02G-023
77:02G-024
77:02I-002

Clay Minerals
77:02F-005

Clays
77:02D-004
77:02G-004
77:02G-008
77:02G-027
77:02G-036
77:02G-054
77:02G-064
77:02G-067
77:02G-088
77:02G-104
77:02G-121
77:02G-130
77:02G-131
77:02G-147
77:02G-173
77:03F-095
77:04D-005
77:05D-001
77:07B-006

Climates
77:02G-129
77:03F-043
77:04A-036
77:05B-024
77:05G-026
77:06D-001
77:06D-002

Climatology
77:02D-006
77:03F-132

Clogging
77:04A-035
77:05G-035

Clovers
77:07B-003

Coastal Plains
77:05G-002

Cohesion
77:02G-070

Cohesionless Soils
77:02J-003

Colorado
77:02I-012
77:03F-098
77:05A-005
77:05B-013
77:05B-055
77:05G-007
77:05G-013
77:05G-014
77:06E-010
77:06E-011
77:07B-035

Colorado River
77:02F-035
77:02G-042
77:05A-005
77:05B-013
77:05G-013
77:05G-014
77:06E-002

Columbia River
77:05G-005

Compaction
77:02F-006
77:02F-013

Compressibility
77:02F-012
77:02F-014
77:02F-047
77:02F-048

Computer Models
77:02D-005
77:02F-001
77:02F-019
77:02F-022
77:02F-025
77:02F-026
77:02F-031
77:02G-014
77:02G-027
77:03F-106
77:05B-026
77:05D-001
77:08B-009

Computer Programs
77:02E-002
77:02F-029
77:02G-107
77:02J-014
77:02J-020
77:02J-038
77:03F-007
77:03F-050
77:03F-129
77:05G-029
77:05G-030
77:07B-010
77:08B-006

Computers
77:02E-001
77:03F-072
77:04B-
77:04D-006
77:05B-047

Concrete
77:08A-001

Conductivity
77:02F-021
77:02F-036
77:02G-015
77:05A-007

Confined Water
77:02F-015
77:02F-023
77:02F-028
77:02F-052

Conjunctive Use
77:04A-001
77:04B-003

Conservation
77:05G-024

Consolidation
77:02F-006
77:02F-013

Constraints
77:03F-018
77:04B-006
77:04B-008
77:05G-018

Consumptive Use
77:02I-002

Contour Farming
77:02E-004

Control
77:04B-001
77:04B-003
77:05G-003

Convections
77:02F-007
77:02F-034
77:05B-022

Conveyance Structures
77:03F-002

Cooling
77:02D-010

Copper
77:05A-006

Cores
77:02G-126
77:05G-033

Corn
77:02D-011
77:02F-027

77:02G-037
77:02G-046
77:02G-053
77:02G-105
77:02G-120
77:02G-141
77:02G-171
77:02I-005
77:02I-013
77:02I-016
77:03F-019
77:03F-023
77:03F-041
77:03F-055
77:03F-065
77:03F-096
77:03F-098
77:03F-126
77:04A-031
77:05B-030
77:05B-036
77:05B-038
77:05B-039
77:05B-042
77:05G-024
77:05G-039

Corn (Field)
77:02D-005
77:02D-009
77:02G-096
77:03F-006
77:04D-005
77:05B-004

Correlation Analysis
77:02D-001
77:02F-003
77:02F-016

Cost Analysis
77:06C-002

Cost Comparisons
77:04A-022
77:06C-002

Cost Repayment
77:03F-135

Cost-Benefit Analysis
77:03F-135

Cost-Benefit Ratio
77:03F-001

Costs
77:03F-005
77:04A-022
77:04B-002
77:04B-003
77:04B-004
77:04D-006
77:05D-001
77:05D-003
77:05G-018
77:06C-002
77:08B-004

Cotton
77:02I-007
77:02I-017
77:03C-001
77:03F-090
77:04A-029
77:05C-004

Crop Production
77:02D-002
77:02D-011
77:02F-027
77:02G-041
77:02G-053
77:02G-073
77:02G-096
77:02G-102
77:02G-104
77:02G-109
77:02G-118
77:02G-136
77:02G-144
77:02G-150
77:02I-001
77:02I-007
77:02I-009
77:02I-011
77:02I-013
77:02I-014
77:02I-016
77:02J-011
77:02L-001
77:03C-001
77:03C-002
77:03F-001
77:03F-004
77:03F-006
77:03F-012
77:03F-013
77:03F-014
77:03F-020
77:03F-026
77:03F-029
77:03F-033
77:03F-034
77:03F-035
77:03F-036
77:03F-037
77:03F-039
77:03F-040
77:03F-041
77:03F-042
77:03F-043
77:03F-044
77:03F-045
77:03F-046
77:03F-047
77:03F-048
77:03F-051
77:03F-052
77:03F-055
77:03F-058
77:03F-061
77:03F-064
77:03F-065
77:03F-067
77:03F-069
77:03F-071
77:03F-075
77:03F-082
77:03F-085
77:03F-088
77:03F-090
77:03F-091
77:03F-098
77:03F-108
77:03F-110
77:03F-112
77:03F-117
77:03F-120
77:03F-121
77:03F-123
77:03F-126
77:03F-128
77:03F-129
77:03F-130
77:03F-131
77:03F-132
77:03F-135
77:03F-136
77:04A-031
77:04A-039
77:04A-040
77:05B-032
77:05B-036
77:05B-038
77:05C-001
77:05C-002
77:05C-004
77:05D-001
77:05G-005
77:05G-011
77:05G-020
77:05G-022
77:05G-026
77:05G-028
77:05G-034
77:06D-002
77:06E-013
77:07B-003
77:07B-014
77:07B-019
77:07B-036

Crop Response
77:02D-002
77:02D-005
77:02F-027
77:02G-036
77:02G-053
77:02G-104
77:02G-120
77:02G-144
77:02G-156
77:02G-157
77:02G-166
77:02G-171
77:02I-001
77:02I-005
77:02I-006
77:02I-007
77:02I-010
77:02I-011
77:02I-013
77:02I-017
77:02L-001
77:03F-003
77:03F-004
77:03F-006
77:03F-011

Crop Response
(cont.)
77:03F-012
77:03F-013
77:03F-014
77:03F-022
77:03F-031
77:03F-033
77:03F-034
77:03F-035
77:03F-036
77:03F-037
77:03F-039
77:03F-041
77:03F-042
77:03F-044
77:03F-047
77:03F-054
77:03F-055
77:03F-058
77:03F-071
77:03F-082
77:03F-090
77:03F-112
77:03F-126
77:03F-130
77:04A-026
77:04A-039
77:05B-028
77:05B-032
77:05G-022
77:07B-003
77:07B-014
77:07B-017

Crops
77:02B-001
77:02D-006
77:02E-004
77:02G-005
77:02G-034
77:04D-005
77:05B-004
77:06A-006
77:06D-002

Crust tests
77:02G-174

Cultivated Lands
77:02J-043

Cultivation
77:02G-007
77:02G-082
77:03F-036
77:03F-087
77:04A-040

Current Meters
77:07B-030

Current (water)
77:02F-007
77:07B-022

Curves
77:02F-037
77:02F-047
77:02F-048
77:02G-012
77:02G-013
77:02G-074
77:02G-095
77:04B-007
77:04D-006

Dams
77:02F-008
77:02F-015

Darcys Law
77:02F-001
77:02F-002
77:02F-028
77:02F-052
77:02G-030
77:02G-032

Data
77:03F-018

Data Collections
77:02G-033
77:02J-003
77:02L-001
77:05B-005
77:07B-005
77:07B-005
77:07B-033
77:08B-016

Data Processing
77:02D-001
77:02F-016
77:02F-036
77:05B-008

Dead Storage
77:02J-015

Decision Making
77:02J-015
77:04A-001
77:04B-004
77:05G-003
77:06B-002

Decomposing Organic Matter
77:02G-099

Deep Percolation
77:05A-005

Deformation
77:02F-006
77:02F-014

Degradation (decomposition)
77:05B-009

Degradation (slope)
77:02J-043

Degradation (stream)
77:02J-043

Demand
77:04A-001
77:04B-004

Demonstration Watersheds
77:02J-011
77:05B-004

Denitrification
77:02G-053
77:02G-062
77:02G-063
77:02G-103
77:02G-105
77:02G-113
77:02G-120
77:02G-165
77:02G-170
77:02I-003
77:02K-005
77:05A-002
77:05B-014
77:05B-025
77:05B-053
77:05E-002
77:07B-015
77:07B-016
77:07B-032
77:07B-034

Density
77:02F-028

Deposition
77:02J-013

Deposition (sediments)
77:04D-004

Depth
77:02F-004
77:02F-006
77:02G-007
77:02G-077
77:02G-082
77:08B-004
77:08B-009

Desalination
77:03A-001
77:05G-007
77:05G-014

Desalination Plants
77:05G-018

Deserts
77:06D-001

Design
77:03F-021
77:08B-007
77:08B-010

Dewatering
77:04B-006

Differentiation
77:02G-095

Diffusion
77:02F-050
77:02G-012
77:02G-013
77:02G-019
77:02G-054
77:02G-077
77:02G-078
77:05B-022

Diffusivity
77:02F-046
77:02G-009
77:02G-019
77:02G-030
77:02G-051
77:02G-056
77:02G-081

Dilution Effects
77:02G-083

Dimensional Analysis
77:08B-002
77:08B-013

Discharge
77:02F-008

Discharge (Water)
77:02F-004
77:02F-025
77:02F-047
77:02F-048
77:02F-052
77:03F-021
77:04B-006
77:04D-003
77:05A-001
77:05G-031
77:08B-002
77:08B-009
77:08B-011
77:08B-016

Discharge coefficient
77:08B-002
77:08B-005
77:08B-011
77:08B-016

Discharge Measurement
77:04A-012
77:08B-011

Discharge Sediments
77:02J-001

Discount Rates
77:04B-008

Dispersion
77:02F-024
77:02F-033
77:02G-018
77:02G-022
77:02G-023
77:02G-024
77:02G-028
77:02G-054
77:02G-124
77:02G-143
77:02G-175
77:05B-002
77:05B-008
77:05B-050

Dissolved Oxygen
77:02F-040
77:02I-018
77:05D-002

Dissolved Solids
77:02F-049
77:05A-003
77:05G-028

Distribution
77:05A-006

Distribution Patterns
77:02G-010
77:04A-023
77:04D-007

Ditches
77:04A-023

Diurnal
77:02G-007

Diversion
77:04B-005

Dolomite
77:02K-002

Domestic Wastes
77:05D-002

Downstream
77:04A-001
77:05G-003
77:05G-032

Drainage
77:02F-032
77:02F-045
77:02F-052
77:02G-025
77:02G-045
77:02G-054
77:02G-060
77:02G-065
77:02G-071
77:02G-072
77:02G-073
77:02G-082
77:02G-116
77:02G-117
77:02G-118
77:02G-122
77:02G-125
77:02G-126
77:02J-013
77:02J-036
77:02J-043
77:03A-001
77:03F-037
77:03F-049
77:03F-065
77:03F-100
77:04A-002
77:04D-003
77:05B-002
77:05B-027
77:05B-046
77:05B-056
77:05D-001
77:05G-001
77:05G-019
77:06B-001
77:08B-009

Drainage Area
77:05G-018

Drainage Districts
77:02G-045
77:02G-072
77:02G-073

Drainage Effects
77:02G-073
77:02G-116
77:02G-117
77:03F-037
77:03F-049
77:03F-065
77:03F-100

Drainage Engineering
77:02G-072
77:02G-092
77:02G-116

Drainage Patterns (Geologic)
77:04D-003

Drainage Practices
77:02G-045
77:02G-072
77:02G-073
77:02G-092
77:02G-116
77:02G-118
77:02G-122
77:04B-002
77:06E-001

Drainage Programs
77:02G-073

Drainage Systems
77:02F-052
77:02G-071
77:02G-072
77:02G-073
77:02G-092
77:02G-116

Drainage Systems
(cont.)
77:02G-118
77:02G-122
77:03F-049
77:04D-005

Drainage Water
77:02I-004
77:03A-001
77:03F-049
77:05B-040
77:05G-001

Drains
77:02F-004
77:02G-072
77:02G-092
77:02G-122
77:08B-008

Drawdown
77:02F-001
77:02F-004
77:02F-006
77:02F-013
77:02F-019
77:02F-023
77:02F-037
77:02F-047
77:02F-048
77:04B-007

Drilling
77:05G-017
77:08B-004

Drilling Fluids
77:05G-017

Drops (Structures)
77:08B-001

Droughts
77:02I-001
77:03F-006

Dry Beds
77:02G-029

Dry Farming
77:02D-002
77:02I-002
77:03F-036

Drying
77:02G-074

Dune Sands
77:03F-004

Dupuit-Forchheimer Theory
77:02F-008
77:02F-018

Dyes
77:07B-001

Dynamic Programming
77:03F-003
77:05G-003

Dynamics
77:07B-022

Earth-Water Interfaces
77:05B-023

Economic Development
77:03F-135

Economic Efficiency
77:03F-018
77:04A-001
77:04B-001
77:04B-004
77:04B-008
77:05G-003
77:05G-018

Economic Feasibility
77:03F-005
77:04A-022

Economic Impact
77:03F-135

Economics
77:02G-117
77L02G-118
77:02J-027
77:02J-045
77:03F-027
77:03F-063
77:03F-068
77:03F-073
77:03F-074
77:03F-109
77:03F-113
77:03F-134
77:03F-135
77:04A-031
77:04A-033
77:04B-002
77:05D-001
77:05G-011
77:05G-012
77:05G-013
77:06A-002
77:06C-001
77:06C-002
77:06E-007
77:08B-006
77:08C-001

Ecosystems
77:02I-018

Education
77:05G-024

Effects
77:02G-005
77:03[illegible]-003
77:04B-002

Efficiencies
77:03F-002

Effluent Limitation
77:05G-021

Effluents
77:02G-015
77:02G-022
77:02K-005
77:05A-001
77:05B-005
77:05B-056
77:05D-007
77:05E-001

Elastic Deformation
77:02F-006

Electrical Conductance
77:02G-015
77:02G-083
77:05B-003
77:05C-001
77:05C-002
77:07B-006

Electrical Engineering
77:07B-030

Electrical Equipment
77:03F-106
77:03F-107
77:05A-009
77:07B-005

Electrical Power
77:03F-106
77:03F-107

Electrical Power Production
77:03F-106
77:03F-107

Electrical Properties
77:05E-002

Electrical Resistance
77:02F-021
77:02F-036

Electricity
77:03F-106
77:03F-107

Electrochemistry
77:05A-009

Electrodes
77:05A-009

Electrolytes
77:02F-005
77:02F-176

Electronic Equipment
77:07B-005

Electronics
77:07B-030

Emulsions
77:03B-001

Energy
77:03F-134
77:03F-136
77:04B-015
77:04D-002
77:08C-001

Energy Equation
77:08B-002

Engineering
77:07B-030

Environment
77:06E-014

Environmental Control
77:03F-027
77:04A-021
77:06E-014

Environmental Effects
77:02G-153
77:02J-004
77:04A-021
77:06A-005
77:06B-002

Environmental Quality
77:03F-132

Environmental Quality Management
77:02G-153

Equations
77:02B-002
77:02D-001
77:02E-001
77:02F-002
77:02F-003
77:02F-004
77:02F-006
77:02F-007
77:02F-008
77:02F-012
77:02F-014
77:02F-015
77:02F-018
77:02F-023
77:02F-037
77:02F-045
77:02F-046
77:02F-047
77:02F-048
77:02F-052
77:02G-009
77:02G-012
77:02G-019
77:02G-020
77:02G-021
77:02G-026
77:02G-027
77:02G-028
77:02G-029
77:02G-048
77:02G-056
77:02G-077
77:02G-079
77:02G-095
77:02G-124
77:02G-125
77:02G-138
77:02G-139
77:02J-010
77:02J-013
77:02J-041
77:02J-042
77:03F-001
77:03F-002
77:03F-003
77:03F-005
77:03F-021
77:04A-001
77:04A-022
77:04A-037
77:04B-001
77:04B-003
77:04B-006
77:04B-007
77:04B-008
77:04B-012
77:04D-006
77:05D-003
77:05G-003
77:05G-018
77:07C-002
77:08B-002
77:08B-011
77:08B-016

Equipment
77:02F-036
77:02G-001
77:02J-002
77:02J-011
77:03F-089
77:07B-005
77:07B-030

Erodibility
77:02G-173

Erosion
77:02B-001
77:02G-079
77:02J-001
77:02J-004
77:02J-010
77:02J-011
77:02J-012
77:02J-013
77:02J-014
77:02J-016
77:02J-020
77:02J-022
77:02J-023
77:02J-025
77:02J-026
77:02J-027
77:02J-028
77:02J-029
77:02J-030
77:02J-033
77:02J-034
77:02J-035
77:02J-036
77:02J-037
77:02J-038
77:02J-040
77:02J-041
77:02J-042
77:02J-043
77:02J-044
77:02J-046
77:03F-020
77:03F-024
77:03F-051
77:03F-052
77:03F-062
77:03F-087
77:04A-021
77:04D-001
77:04D-006
77:05B-030
77:05G-022
77:05G-023
77:05G-025
77:06A-001
77:06E-007
77:07B-011

Erosion Rates
77:02J-001
77:02J-010
77:02J-012
77:02J-028
77:02J-040

Estimating
77:02D-001
77:02G-011
77:02J-015
77:02J-041
77:03F-005
77:03F-018

Eutrophication
77:05B-046
77:05C-003

Evaluation
77:02F-003
77:02G-001
77:02J-004
77:03F-001
77:03F-005
77:05B-005

Evaporation
77:02D-001
77:02D-004
77:02D-009
77:02D-010
77:02D-011
77:02G-049
77:02G-060
77:02G-082
77:02G-137
77:02L-001
77:03F-038
77:03F-086
77:03F-097
77:05B-021

Evaporation Pans
77:03F-001

Evapotranspiration
77:02D-001
77:02D-003
77:02D-005
77:02D-006
77:02D-007
77:02D-009
77:02G-008
77:02G-014
77:02G-032
77:02G-049
77:02G-096
77:02G-129
77:02G-142
77:02I-016
77:03F-001
77:03F-008
77:03F-011
77:03F-023
77:03F-037
77:03F-039
77:03F-040
77:03F-054
77:03F-094
77:03F-115
77:03F-126
77:04B-013
77:05B-021
77:05B-024
77:07B-036

Expansive Clays
77:05B-007

Exploration
77:08B-004

Farm Equipment
77:04B-015

Farm Management
77:02E-004
77:02L-001
77:04D-006
77:05G-023

Farm Ponds
77:05D-001

Farm Wastes
77:02B-001
77:05B-031
77:05G-023

Farms
77:05B-031

Feasibility Studies
77:04A-022

Federal Government
77:06E-013

Federal Reclamation Law
77:05G-021

Federal Water Pollution
Control Act
77:05G-021
77:05G-023

Fertilization
77:02G-009
77:02G-037
77:02G-038
77:02G-053
77:02G-059
77:02G-062
77:02G-104
77:02G-105
77:02G-120
77:02G-147
77:02G-149
77:02G-150
77:02G-157
77:02G-163
77:02G-171
77:02I-012
77:02J-008
77:02J-046
77:03F-004
77:03F-013
77:03F-014
77:03F-031
77:03F-032
77:03F-033
77:03F-043
77:03F-047
77:03F-056
77:03F-090
77:03F-091
77:03F-102
77:03F-108
77:03F-109
77:03F-127
77:03F-129
77:03F-130
77:03F-131
77:03F-132
77:04B-013
77:05A-003
77:05B-014
77:05B-017
77:05B-035
77:05B-038
77:05B-041
77:05B-043
77:05B-055
77:05D-009
77:05G-004
77:05G-005
77:05G-022
77:05G-027
77:07B-014
77:07B-015
77:07B-033
77:07B-035

Fertilizers
77:02B-001
77:02G-036
77:02G-037
77:02G-038
77:02G-040
77:02G-053
77:02G-057
77:02G-059
77:02G-062
77:02G-096
77:02G-097
77:02G-104
77:02G-105
77:02G-120
77:02G-134
77:02G-135
77:02G-147
77:02G-149
77:02G-150
77:02G-157
77:02G-163
77:02G-171
77:02G-175
77:02I-012
77:02J-008
77:02J-046
77:03F-013
77:03F-014
77:03F-022
77:03F-031
77:03F-032
77:03F-033
77:03F-043
77:03F-045
77:03F-047
77:03F-056
77:03F-057
77:03F-078
77:03F-102
77:03F-108
77:03F-109
77:03F-116
77:03F-127
77:03F-129
77:03F-130
77:03F-131
77:03F-132
77:04B-013
77:04B-015
77:05B-010
77:05B-011
77:05B-014
77:05B-025
77:05B-035
77:05B-038
77:05B-041
77:05B-042
77:05B-043
77:05B-055
77:05C-005
77:05G-004
77:05G-005
77:05G-011
77:05G-023
77:05G-027
77:07B-014
77:07B-015
77:07B-018
77:07B-033
77:07B-035

Field Crops
77:02E-004
77:03F-029

Filters
77:04D-004
77:05D-004
77:07B-001

Filtration
77:02G-019
77:03F-030
77:04A-035
77:05D-004

Financing
77:06C-002

Finite Difference Analysis
77:02G-175

Finite Element Analysis
77:02F-006
77:02F-012
77:02F-026
77:02G-128
77:04B-001
77:05B-008

Fissures (Geologic)
77:02F-047
77:02F-048

Flood Control
77:04A-022
77:05B-027
77:05G-032
77:06B-002

Flood Irrigation
77:03F-123
77:04A-026

Flood Protection
77:04A-022

Florida
77:03F-091
77:05B-027
77:05B-041
77:05G-017

Flow
77:02E-001
77:02E-005
77:02F-002
77:02F-004
77:02F-012
77:02F-014
77:02F-017
77:02F-019
77:02F-025
77:02F-047
77:02F-052
77:02G-012
77:02G-030
77:02G-031
77:02G-142
77:03F-005
77:03F-089
77:04A-023
77:04B-001
77:04D-007
77:05B-021
77:07B-030
77:08B-001
77:08B-003
77:08B-007
77:08B-008
77:08B-016

Flow Characteristics
77:02F-040

Flow Measurement
77:03F-089
77:04A-011
77:04A-012
77:07B-022
77:07B-024
77:07B-025
77:07B-026
77:07B-027
77:07B-028
77:07B-029
77:08B-007

Flow Nets
77:02F-008

Flow Profiles
77:02E-001

Flow Rates
77:04A-011
77:04A-012
77:04A-037
77:05G-035
77:07B-028
77:08B-012
77:08B-014
77:08B-015

Flow Resistance
77:03F-087

Flowering
77:02I-001

Flowmeters
77:08B-011
77:08B-016

Fluctuations
77:02F-020
77:02F-032
77:05B-020

Fluid Friction
77:02F-007

Fluid Mechanics
77:02F-002
77:02F-007
77:04D-007

Flumes
77:04A-011
77:05A-001
77:07B-024
77:07B-027
77:07B-029
77:08B-007

Fluorescent Dye
77:07B-001

Fluorides
77:05B-005

Fly Ash
77:02G-168

Forecasting
77:02F-010
77:02G-005
77:02J-013
77:03F-086
77:04B-005
77:04D-006
77:05B-021

Foreign Countries
77:02D-004
77:02D-006
77:02D-008

Foreign Research
77:02D-004
77:02D-006
77:02D-008
77:02F-025
77:02G-033
77:05A-003
77:07B-002

Forest Watersheds
77:02G-014

Formulas
77:02B-002

Fraction Permeability
77:02F-012

Free Surfaces
77:02F-009

Freezing
77:02C-001

Frequency Analysis
77:04B-002

Friction
77:08B-002
77:08B-014
77:08B-015

Fringe Water
77:02G-033

Frost
77:02C-001

Frost Action
77:02C-001

Frost Protection
77:02D-010

Frozen Ground
77:02C-001

Frozen Soils
77:02C-001

Fruit Crops
77:02D-010
77:02G-049

Furrow Irrigation
77:02G-037
77:02J-010
77:03F-023
77:03F-042
77:03F-062
77:03F-065
77:03F-083
77:03F-087
77:03F-120
77:03F-123
77:04A-004
77:04A-020
77:04A-037
77:04A-038
77:04A-040
77:05B-042
77:05G-005
77:06C-002
77:07B-021

Furrow Systems
77:04A-038
77:04A-040

Furrows
77:03F-087

Gages
77:03F-089

Gate Control
77:08B-003

Gates
77:04A-038
77:08B-003

Geochemistry
77:02F-016
77:05A-006
77:07B-002

Geohydrologic Units
77:02F-010

Geology
77:02F-021
77:05B-049

Geomorphology
77:02J-043
77:02K-002

Geophysics
77:02F-005
77:02F-021

Georgia
77:02E-003

Germination
77:02I-001
77:03C-001
77:03F-042
77:03F-044

Glacial Drift
77:02F-021
77:05B-049
77:05D-005

Glucose
77:02G-113
77:02G-161
77:02G-162

Government Interrelations
77:05G-021

Governments
77:03F-135

Gradually Varied Flow
77:02E-001

Grain Sorghum
77:02D-002
77:04A-039
77:04A-040
77:05G-039

Grain Yield
77:05G-039

Grain (Crops)
77:02I-016
77:03F-006

Graphical Analysis
77:02E-001
77:02F-008
77:02F-037
77:04B-007

Graphical Methods
77:02E-001

Grassed Waterways
77:02E-005
77:04D-004
77:05G-002

Grasses
77:02D-006
77:03F-014
77:04D-004

Gravimetric Analysis
77:02G-047

Gravimetry
77:02G-047

Gravitational Water
77:04A-027

Greenhouses
77:02G-008
77:02I-009
77:02I-013
77:05B-032

Groundwater
77:02F-005
77:02F-007
77:02F-011
77:02F-014
77:02F-016
77:02F-017
77:02F-018
77:02F-019
77:02F-020
77:02F-021
77:02F-023
77:02F-024
77:02F-025
77:02F-026
77:02F-027
77:02F-030
77:02F-032
77:02F-033
77:02F-034
77:02F-035
77:02F-036
77:02F-038
77:02F-039
77:02F-040
77:02F-042
77:02F-043
77:02F-044
77:02F-045
77:02F-046
77:02F-049
77:02F-050
77:02F-051
77:02G-023
77:02G-024
77:02G-025
77:02G-030
77:02G-048
77:02G-054
77:02G-124
77:02J-011
77:02K-002
77:03F-056
77:04A-001
77:04A-003
77:04B-003
77:04B-004
77:04B-005
77:04B-006
77:04B-008
77:04B-010
77:04B-011
77:04B-012
77:04B-013
77:04B-014
77:04D-001
77:05A-005
77:05A-006
77:05A-007
77:05B-010
77:05B-016
77:05B-017
77:05B-018
77:05B-019
77:05B-020
77:05B-021
77:05B-022
77:05B-024
77:05B-031
77:05B-034
77:05B-045
77:05B-056
77:05D-009
77:05G-017
77:05G-022
77:05G-028
77:05G-038
77:07B-002
77:07B-010

Groundwater Barriers
77:04B-011

Groundwater Basins
77:02F-027
77:02F-035
77:02F-043
77:02F-044

Groundwater Flow
77:02F-028

Groundwater Mining
77:02F-044

Groundwater Movement
77:02F-001
77:02F-002
77:02F-003
77:02F-004
77:02F-007
77:02F-009
77:02F-010
77:02F-011
77:02F-014
77:02F-015
77:02F-017
77:02F-018
77:02F-019
77:02F-020
77:02F-022
77:02F-025
77:02F-026
77:02F-029
77:02F-030
77:02F-033
77:02F-034
77:02F-038
77:02F-039
77:02F-040
77:02F-045
77:02F-047
77:02F-048
77:02F-049
77:02F-050
77:02G-011
77:02G-023
77:02G-024
77:02G-025
77:02G-030
77:02G-048
77:05A-007
77:05B-008
77:05B-016
77:05B-017
77:05B-018
77:05B-019
77:05B-021
77:05B-045

Groundwater Potential
77:02F-021
77:02F-027
77:02F-043
77:08B-008

Groundwater Recharge
77:02F-004
77:02F-020
77:02F-031
77:02F-032
77:02F-035
77:02F-044
77:04B-011
77:05A-007
77:05B-018
77:05B-019

Groundwater Resources
77:02F-016
77:02F-020
77:02F-021
77:02F-027
77:02F-035
77:02F-038
77:02F-039
77:02F-042
77:02F-043
77:02F-044
77:02F-050
77:02F-051
77:04B-001
77:04B-013

Growth Rates
77:05D-002

Growth Stages
77:02I-010
77:02I-011

Gullies
77:02J-043

Gully Erosion
77:04D-001

Gypsum
77:05G-001

Halides
77:05B-002

Hardness (Water)
77:02F-030
77:05B-005

Hawaii
77:03F-001
77:05B-009

Hazards
77:05B-031

Head Loss
77:08B-002
77:08B-014
77:08B-015

Heat
77:02G-051

Heat Flow
77:02D-008
77:02F-034

Heat Pollution
77:05B-007

Heat Transfer
77:02F-007
77:02F-034
77:02G-006
77:05B-022

Heated Water
77:02F-034
77:05B-002

Heavy Metals
77:02G-067
77:02G-090
77:02I-013
77:02I-019
77:02J-038
77:02K-003
77:05A-006
77:05B-023
77:05B-045
77:05D-005
77:07B-017

Height
77:02I-011

Herbicides
77:03F-020
77:03F-098
77:03F-133
77:05B-006
77:05B-009
77:05B-034
77:05G-002

Herbigation
77:03F-133

History
77:02J-043

Horizontal Infiltration
77:02G-056

Hortans Law
77:02G-028

Humid Areas
77:02G-007

Humid Climates
77:02G-007

Hydraulic Conductivity
77:02B-002
77:02D-004
77:02D-009
77:02D-011
77:02F-011
77:02F-014
77:02F-022
77:02F-028
77:02F-029
77:02F-032
77:02F-033
77:02F-036
77:02F-037
77:02F-045
77:02F-049

Hydraulic Conductivity
(cont.)
77:02G-002
77:02G-009
77:02G-010
77:02G-016
77:02G-017
77:02G-023
77:02G-024
77:02G-025
77:02G-027
77:02G-030
77:02G-031
77:02G-032
77:02G-033
77:02G-035
77:02G-043
77:02G-046
77:02G-061
77:02G-080
77:02G-081
77:02G-092
77:02G-115
77:02G-125
77:02G-126
77:02G-127
77:02G-128
77:02G-168
77:02G-174
77:02G-175
77:02G-176
77:03F-010
77:03F-011
77:03F-095
77:04A-023
77:04A-025
77:04B-006
77:04B-007
77:04D-003
77:05B-016
77:08B-008
77:02G-081
77:02G-082
77:02G-176

Hydraulic Design
77:04A-013
77:04A-014
77:08B-006
77:08B-010
77:08B-012
77:08B-013
77:08B-014
77:08B-015

Hydraulic Gradient
77:02F-046
77:02G-176

Hydraulic Jump
77:08B-001

Hydraulic Models
77:02G-033
77:04D-004

Hydraulic Properties
77:02F-004
77:02F-022
77:02F-047
77:02F-048
77:02G-031
77:02G-032

Hydraulic Structures
77:02F-015

Hydraulics
77:02E-001
77:02E-005
77:02F-011
77:02F-052
77:02J-003
77:04A-011
77:04A-013
77:04A-014
77:04A-015
77:04A-024
77:04A-027
77:04B-012
77:04D-007
77:05A-001
77:05B-047
77:05G-003
77:07B-027
77:08B-001
77:08B-002
77:08B-003
77:08B-005
77:08B-006
77:08B-007
77:08B-009
77:08B-010
77:08B-011
77:08B-012
77:08B-013
77:08B-014
77:08B-015
77:08B-016

Hydrodynamics
77:02F-011
77:02F-038
77:02G-023
77:02G-024
77:02G-111
77:04A-019
77:05B-034
77:05B-047

Hydrogen
77:05B-029

Hydrogen Ion Concentration
77:02K-002
77:05A-006
77:05D-002

Hydrogeology
77:02F-003
77:02F-010
77:02F-021
77:02F-029
77:02F-030
77:05B-019

Hydrograph Analysis
77:02E-005

Hydrographs
77:02B-002
77:02F-046
77:02J-007
77:05B-027
77:07B-005

Hydrography
77:04D-003

Hydrologic Aspects
77:02D-001
77:02G-014
77:04A-022

Hydrologic Budget
77:02G-032

Hydrologic Data
77:02J-004
77:07B-005

Hydrologic Properties
77:02F-036
77:02J-004

Hydrologic Systems
77:02G-014

Hydrology
77:02E-002
77:02E-003
77:02E-005
77:02F-007
77:02F-014
77:02F-017
77:02F-018
77:02F-025
77:02F-026
77:02F-030
77:02F-036
77:02F-045
77:02F-049
77:02G-014
77:02G-025
77:02G-031
77:02G-093
77:02G-128
77:02G-142
77:02J-010
77:02J-020
77:04B-002
77:04B-005
77:04B-011
77:04D-003
77:04D-006
77:05B-018
77:05B-019
77:05B-027
77:05G-004
77:05G-038
77:05G-040
77:06E-001
77:07B-005
77:07B-030

Hydrometry
77:02G-091

Hysteresis
77:02C-001
77:02G-013
77:02G-030
77:02G-033
77:02G-035
77:02G-065
77:02G-074
77:02G-094

Ice
77:02C-001

Idaho
77:02E-002
77:02F-041
77:02J-011
77:03B-001
77:03F-042
77:04A-006
77:05B-035

Illinois
77:02G-113
77:05D-001

Illite
77:02G-004

Immiscibility
77:02G-083

Immobilization
77:02G-104

Impact (Rainfall)
77:02G-050
77:02G-079
77:02J-001

Impervious Soils
77:05D-001

Impoundment
77:08B-009

Incentives
77:05G-024

Income
77:03F-018

Indexing
77:02D-007

Indiana
77:03F-024

Industrial Plants
77:05A-001

Industrial Wastes
77:05D-002

Infiltration
77:02B-002
77:02F-011
77:02F-025
77:02F-031
77:02G-002
77:02G-011
77:02G-014
77:02G-017
77:02G-018
77:02G-027
77:02G-028
77:02G-029
77:02G-030
77:02G-032
77:02G-035
77:02G-046
77:02G-048
77:02G-050
77:02G-056
77:02G-058
77:02G-071
77:02G-075
77:02G-076
77:02G-082
77:02G-087
77:02G-093
77:02G-095
77:02G-123
77:02G-127
77:02G-128
77:02G-137
77:02G-138
77:02G-139
77:02G-140
77:02G-141
77:02G-142
77:02I-008
77:04A-017
77:04A-023
77:04A-036
77:05B-008
77:05B-029
77:05D-004
77:05E-002
77:07B-024
77:07C-002

Infiltration Rates
77:02G-028
77:02G-029
77:02G-050

Inflow
77:02F-008
77:02J-044
77:04A-003
77:05G-031
77:08B-008
77:08B-009

Infrared Radiation
77:03F-082

Injection
77:05G-036

Injection Wells
77:04B-011
77:05B-022
77:05E-001
77:05G-017

Input-Output Analysis
77:02D-005
77:04B-012

Instrumentation
77:02G-016
77:02G-047
77:02J-011
77:02L-001
77:05A-001
77:07B-002
77:07B-030
77:08B-007

Instruments
77:07B-026

Inter-Basin Transfers
77:04A-022
77:04B-005

Interfaces
77:05B-023

Iodine
77:02G-054

Iodine Radioisotopes
77:02G-054

Ion Exchange
77:02G-077
77:02G-081
77:02G-106
77:05D-005
77:05G-034

Ion Transport
77:05B-050

Ions
77:02F-016
77:02F-040
77:02G-080
77:02G-084
77:02G-101
77:02K-001
77:05B-050

Iowa
77:02D-001
77:02G-119
77:02J-040
77:02J-043
77:02J-046
77:05B-004
77:07B-020

Iron
77:02G-086
77:05A-002
77:05A-006
77:05B-026

Irrigated Land
77:02K-005
77:03C-001
77:03F-007
77:03F-057

Irrigation
77:02F-027
77:02F-041
77:02F-043
77:02F-044

Irrigation
(cont.)
77:02G-006
77:02G-015
77:02G-026
77:02G-037
77:02G-039
77:02G-041
77:02G-043
77:02G-048
77:02G-049
77:02G-055
77:02G-058
77:02G-061
77:02G-096
77:02G-103
77:02G-115
77:02G-123
77:02G-126
77:02G-135
77:02G-136
77:02G-144
77:02G-147
77:02G-152
77:02G-171
77:02G-175
77:02I-003
77:02I-007
77:02I-010
77:02J-010
77:02J-014
77:02J-037
77:02K-005
77:03A-001
77:03C-001
77:03C-002
77:03F-001
77:03F-002
77:03F-007
77:03F-009
77:03F-010
77:03F-011
77:03F-019
77:03F-023
77:03F-034
77:03F-035
77:03F-036
77:03F-037
77:03F-040
77:03F-042
77:03F-044
77:03F-045
77:03F-050
77:03F-054
77:03F-056
77:03F-059
77:03F-060
77:03F-061
77:03F-062
77:03F-064
77:03F-065
77:03F-067
77:03F-069
77:03F-071
77:03F-073
77:03F-074
77:03F-075
77:03F-077
77:03F-078
77:03F-079
77:03F-080
77:03F-081
77:03F-082
77:03F-084
77:03F-085
77:03F-089
77:03F-090
77:03F-091
77:03F-092
77:03F-094
77:03F-096
77:03F-099
77:03F-100
77:03F-102
77:03F-103
77:03F-104
77:03F-105
77:03F-106
77:03F-107
77:03F-113
77:03F-114
77:03F-115
77:03F-116
77:03F-118
77:03F-119
77:03F-121
77:03F-122
77:03F-123
77:03F-124
77:03F-125
77:03F-133
77:03F-134
77:03F-135
77:04A-001
77:04A-002
77:04A-006
77:04A-008
77:04A-009
77:04A-010
77:04A-012
77:04A-013
77:04A-014
77:04A-018
77:04A-019
77:04A-020
77:04A-021
77:04A-025
77:04A-027
77:04A-028
77:04A-030
77:04A-034
77:04A-035
77:04A-036
77:04A-042
77:04B-009
77:04B-011
77:04D-005
77:05A-004
77:05B-006
77:05B-011
77:05B-017
77:05B-024
77:05B-035
77:05B-042
77:05B-050
77:05B-055
77:05C-001
77:05C-002
77:05C-005
77:05D-001
77:05D-009
77:05G-003
77:05G-005
77:05G-007
77:05G-008
77:05G-010
77:05G-011
77:05G-012
77:05G-013
77:05G-018
77:05G-020
77:05G-021
77:05G-022
77:05G-027
77:05G-028
77:05G-029
77:05G-030
77:05G-037
77:05G-040
77:06A-002
77:06A-006
77:06C-001
77:06D-002
77:06E-004
77:06E-005
77:06E-012
77:07B-010
77:07B-035
77:08A-001
77:08B-006
77:07C-001

Irrigation Canals
77:02G-048
77:05G-036

Irrigation Design
77:02G-087
77:02G-141
77:03F-029
77:03F-068
77:03F-081
77:03F-100
77:03F-103
77:04A-013
77:04A-014
77:04A-017
77:04A-024
77:04A-032
77:04A-038
77:08B-006
77:08B-010
77:08B-012
77:08B-013
77:08B-014
77:08B-015

Irrigation Districts
77:03F-005
77:04A-005
77:05G-021

Irrigation Ditches
77:02G-048
77:03F-089

Irrigation Effects
77:02F-041
77:02G-006
77:02G-103

Irrigation Effects
(cont.)
77:02G-115
77:02G-136
77:02G-144
77:02G-145
77:02G-147
77:02G-152
77:02G-171
77:02I-007
77:03F-004
77:03F-010
77:03F-011
77:03F-019
77:03F-034
77:03F-035
77:03F-036
77:03F-037
77:03F-042
77:03F-056
77:03F-059
77:03F-060
77:03F-061
77:03F-064
77:03F-065
77:03F-078
77:03F-080
77:03F-086
77:03F-096
77:03F-099
77:03F-100
77:03F-102
77:03F-112
77:03F-115
77:03F-116
77:03F-119
77:03F-126
77:04A-021
77:04A-030
77:05B-003
77:05B-010
77:05B-042
77:05B-044
77:05B-055
77:05C-001
77:05D-009
77:05G-012
77:05G-019
77:05G-020
77:05G-027
77:05G-029
77:05G-030
77:05G-037
77:06E-012
77:07B-010
77:07B-015
77:07B-021
77:07B-035

Irrigation Efficiency
77:02G-042
77:02G-044
77:03A-001
77:03F-008
77:03F-009
77:03F-019
77:03F-021
77:03F-028
77:03F-036
77:03F-054
77:03F-056
77:03F-059
77:03F-060
77:03F-062
77:03F-067
77:03F-069
77:03F-071
77:03F-075
77:03F-076
77:03F-078
77:03F-089
77:03F-092
77:03F-094
77:03F-097
77:03F-100
77:03F-101
77:03F-104
77:03F-105
77:03F-113
77:03F-117
77:03F-121
77:03F-122
77:03F-123
77:03F-124
77:03F-125
77:04A-003
77:04A-004
77:04A-007
77:04A-008
77:04A-010
77:04A-012
77:04A-020
77:04A-027
77:04A-029
77:04A-032
77:04A-034
77:04A-035
77:04A-037
77:04A-038
77:04B-015
77:05G-022
77:07B-036
77:08B-010
77:08B-012
77:08C-001

Irrigation Engineering
77:03F-068
77:03F-089
77:04A-013
77:04A-018
77:04A-019
77:04A-020
77:04A-027
77:04A-032
77:04A-033
77:05B-047
77:05G-001
77:08B-010
77:08B-012
77:08B-013
77:08B-014
77:08B-015

Irrigation Methods
77:03F-083
77:03F-094
77:03F-097
77:08B-010

Irrigation Practices
77:02D-005
77:02G-055
77:02G-061
77:02G-087
77:02G-136
77:02J-011
77:02L-001
77:03F-004
77:03F-009
77:03F-010
77:03F-011
77:03F-019
77:03F-021
77:03F-028
77:03F-029
77:03F-030
77:03F-042
77:03F-044
77:03F-050
77:03F-068
77:03F-069
77:03F-070
77:03F-073
77:03F-074
77:03F-076
77:03F-077
77:03F-078
77:03F-081
77:03F-082
77:03F-083
77:03F-084
77:03F-085
77:03F-086
77:03F-091
77:03F-092
77:03F-094
77:03F-097
77:03F-098
77:03F-101
77:03F-102
77:03F-103
77:03F-104
77:03F-105
77:03F-106
77:03F-107
77:03F-113
77:03F-114
77:03F-115
77:03F-118
77:03F-121
77:03F-122
77:03F-124
77:03F-125
77:03F-133
77:04A-006
77:04A-010
77:04A-018
77:04A-019
77:04A-021
77:04A-024
77:04A-025
77:04A-026
77:04A-027
77:04A-028
77:04A-029
77:04A-031
77:04A-033
77:04A-034
77:04A-035

Irrigation Practices
(cont.)
77:04A-036
77:04A-038
77:04B-009
77:04B-015
77:05B-042
77:05C-002
77:05G-013
77:05G-021
77:05G-022
77:05G-038
77:06C-002
77:07B-021
77:07B-035
77:09C-001
77:06E-012

Irrigation Return Flow
77:05G-021

Irrigation Systems
77:02F-036
77:02G-037
77:02G-061
77:02G-087
77:02G-123
77:02G-141
77:02J-010
77:03F-003
77:03F-005
77:03F-009
77:03F-010
77:03F-011
77:03F-021
77:03F-023
77:03F-028
77:03F-029
77:03F-030
77:03F-057
77:03F-061
77:03F-067
77:03F-068
77:03F-070
77:03F-076
77:03F-079
77:03F-080
77:03F-081
77:03F-083
77:03F-084
77:03F-086
77:03F-090
77:03F-091
77:03F-092
77:03F-101
77:03F-103
77:03F-104
77:03F-114
77:03F-118
77:03F-121
77:03F-122
77:03F-124
77:03F-125
77:03F-127
77:03F-136
77:04A-003
77:04A-008
77:04A-010
77:04A-013
77:04A-014
77:04A-018
77:04A-019
77:04A-020
77:04A-024
77:04A-026
77:04A-027
77:04A-028
77:04A-029
77:04A-033
77:04A-034
77:04A-035
77:04A-036
77:04A-038
77:04A-039
77:04A-040
77:04A-041
77:05B-010
77:05G-013
77:05G-022
77:05G-035
77:06C-001
77:06C-002
77:08A-001
77:08B-012
77:08B-014
77:08B-015
77:09C-001

Irrigation Water
77:02G-115
77:02G-135
77:02I-008
77:02I-016
77:02K-001
77:03C-001
77:03F-008
77:03F-030
77:03F-057
77:03F-062
77:03F-071
77:03F-073
77:03F-074
77:04A-004
77:04A-006
77:04A-009
77:04A-011
77:04A-020
77:04A-040
77:05B-003
77:05B-011
77:05B-037
77:05B-040
77:05B-041
77:05B-042
77:05C-002
77:05G-020
77:05G-028
77:06D-002
77:06E-010
77:06E-012

Irrigation Wells
77:02K-001
77:08C-001

Islands
77:02F-020

Isotope Studies
77:03F-015
77:03F-016

Isotopes
77:02G-113
77:02G-165
77:05C-005

Kansas
77:02D-005
77:02G-129

Karst
77:02K-002

Karst Hydrology
77:02K-002

Kinetics
77:02G-062
77:02G-078
77:02G-148

Laboratory Equipment
77:02G-008
77:02I-009
77:07B-004

Laboratory Studies
77:02G-154
77:07B-031

Laboratory Tests
77:02D-003
77:02D-004
77:02D-009
77:02E-005
77:02G-001
77:02G-002
77:02G-004
77:02G-006
77:02G-010
77:02G-012
77:02G-013
77:02G-015
77:02G-016
77:02G-022
77:02G-023
77:02G-024
77:02G-030
77:02G-033
77:02G-048
77:02G-056
77:02G-058
77:02G-077
77:02G-081
77:02G-083
77:02G-099
77:02G-112
77:02G-126
77:02G-173
77:02I-009
77:02J-001

Laboratory Tests
(cont.)
77:02J-003
77:02J-044
77:02K-002
77:04A-023
77:04A-025
77:04D-004
77:05A-003
77:05B-001
77:05B-018
77:05B-053
77:05B-056
77:05D-004
77:05D-005
77:05G-036
77:07B-001
77:07B-004
77:07B-012
77:07B-013
77:07B-018
77:07B-030
77:07B-034
77:07B-035
77:08B-002
77:08B-003
77:08B-011
77:08B-016

Lagoons
77:02G-100
77:05D-008

Lake Erie
77:05B-049

Lake Sediments
77:02J-013

Lakes
77:02J-013
77:05B-027
77:05B-049
77:05G-032
77:05G-034

Land
77:03F-017
77:06E-014

Land Classification
77:03F-017
77:03F-053
77:06E-014

Land Development
77:03F-017
77:03F-026
77:03F-053
77:06E-014

Land Management
77:02J-008
77:02J-042
77:03F-053
77:04D-005
77:05B-017
77:06E-014

Land Reclamation
77:03F-033
77:05D-008

Land Resources
77:02J-008
77:03F-017
77:03F-048
77:03F-053
77:06E-014

Land Subsidence
77:02F-013

Land Use
77:02J-008
77:03F-017
77:03F-026
77:03F-053
77:03F-132
77:05B-025
77:05B-027
77:05B-031
77:06E-014

Laplaces Equation
77:08B-008

Latitudinal Studies
77:03F-038

Law Enforcement
77:02F-042

Laws
77:02G-122

Leachate
77:02B-001
77:02G-001
77:05B-013
77:05B-017
77:05B-045
77:05B-056

Leaching
77:02G-001
77:02G-010
77:02G-015
77:02G-018
77:02G-036
77:02G-038
77:02G-041
77:02G-042
77:02G-057
77:02G-062
77:02G-064
77:02G-077
77:02G-078
77:02G-096
77:02G-101
77:02G-103
77:02G-154
77:02I-008
77:03F-004
77:03F-008
77:03F-033
77:03F-045
77:04A-002
77:04A-030
77:04B-009
77:04B-013
77:05B-001
77:05B-002
77:05B-003
77:05B-004
77:05B-006
77:05B-014
77:05B-024
77:05B-025
77:05B-032
77:05B-036
77:05B-038
77:05B-039
77:05B-042
77:05B-045
77:05B-048
77:05B-056
77:05C-001
77:05G-001
77:05G-004
77:05G-016
77:05G-026
77:06B-001
77:07B-003
77:07B-015
77:07B-020
77:07B-031

Lead
77:02G-067
77:02I-013
77:02I-019
77:05A-006
77:05B-054
77:05D-005

Leakage
77:02F-025
77:02F-029
77:02F-037

Leases
77:06C-002

Least Squares Method
77:02F-010

Leaves
77:02D-002
77:02D-009
77:02I-009
77:02I-010
77:03F-034
77:03F-035
77:03F-112

Legal Aspects
77:02F-035
77:05G-003
77:06E-006
77:06E-008

Legislation
77:02F-035
77:06E-006
77:06E-008

Legumes
77:07B-003

Limestones
    77:02F-030
    77:02F-040
    77:02F-049
    77:02K-002

Limnology
    77:05B-054
    77:05C-003
    77:05G-034

Linear Programming
    77:03F-018
    77:04B-001
    77:04B-006
    77:04B-008
    77:04B-012

Linings
    77:05G-037

Liquid Wastes
    77:02G-143

Littoral
    77:07B-002

Loads (Forces)
    77:02G-176

Loam
    77:02D-004
    77:02G-010
    77:02G-011
    77:02G-022
    77:02G-081
    77:02G-082
    77:02J-044

Loess
    77:02J-043
    77:04D-001

Long-Term Planning
    77:04B-001

Louisiana
    77:02G-109

Low Flow
    77:04B-005
    77:05A-001

Low-Flow Augmentation
    77:04A-022

Lysimeters
    77:02D-003
    77:02G-001
    77:02G-010
    77:02G-036
    77:02G-057
    77:02G-060
    77:02G-065
    77:03F-054
    77:03F-056
    77:03F-064
    77:04A-039
    77:05B-002
    77:05B-003
    77:05B-014
    77:05B-039
    77:05G-019
    77:05G-027
    77:07B-003

Magnesium
    77:02F-016
    77:02G-066
    77:02G-107
    77:03F-032
    77:04B-009
    77:05B-049

Maize
    77:05B-032

Management
    77:04A-001
    77:04A-040
    77:04A-042
    77:04B-003
    77:04B-006
    77:04B-012
    77:05D-003
    77:05G-001
    77:06B-002

Manganese
    77:03F-032
    77:05A-006

Mannings Equation
    77:02E-005

Manure
    77:04B-009

Marine Biology
    77:05B-009

Maryland
    77:05B-031

Mass Transfer
    77:02G-012
    77:02G-013

Materials
    77:02G-016

Materials Engineering
    77:02G-016

Materials Testing
    77:02G-016

Mathematical Analysis
    77:02J-019

Mathematical Models
    77:02B-002
    77:02C-001
    77:02D-001
    77:02D-004
    77:02D-009
    77:02D-011
    77:02F-003
    77:02F-004
    77:02F-006
    77:02F-007
    77:02F-008
    77:02F-009
    77:02F-011
    77:02F-012
    77:02F-013
    77:02F-014
    77:02F-015
    77:02F-018
    77:02F-019
    77:02F-020
    77:02F-023
    77:02F-025
    77:02F-026
    77:02F-028
    77:02F-031
    77:02F-032
    77:02F-033
    77:02F-034
    77:02F-045
    77:02F-046
    77:02F-047
    77:02F-048
    77:02F-049
    77:02G-002
    77:02G-003
    77:02G-005
    77:02G-010
    77:02G-011
    77:02G-012
    77:02G-013
    77:02G-014
    77:02G-015
    77:02G-017
    77:02G-019
    77:02G-021
    77:02G-022
    77:02G-026
    77:02G-027
    77:02G-028
    77:02G-033
    77:02G-035
    77:02G-048
    77:02G-050
    77:02G-056
    77:02G-058
    77:02G-060
    77:02G-074
    77:02G-077
    77:02G-080
    77:02G-124
    77:02G-125
    77:02G-126
    77:02G-127
    77:02G-128
    77:02G-142
    77:02G-143
    77:02G-175
    77:02J-013
    77:02J-041
    77:02J-042
    77:03F-001
    77:03F-003
    77:03F-005
    77:03F-018
    77:03F-136
    77:04A-023
    77:04B-001
    77:04B-002
    77:04B-003
    77:04B-004

Mathematical Models (cont.)
  77:04B-006
  77:04B-008
  77:04B-012
  77:04D-004
  77:04D-007
  77:05B-001
  77:05B-004
  77:05B-008
  77:05B-016
  77:05B-021
  77:05B-022
  77:05B-026
  77:05B-027
  77:05B-047
  77:05D-003
  77:05G-018
  77:06A-006
  77:08B-008
  77:08B-009

Mathematical Simulation
  77:05G-007

Mathematical Studies
  77:02F-002
  77:02F-012
  77:02F-017
  77:02F-024
  77:02F-039
  77:02F-050
  77:02G-020
  77:02G-029
  77:02G-047
  77:02G-051
  77:02G-062
  77:02G-079
  77:02J-015
  77:03F-072
  77:04B-007
  77:04B-010
  77:05B-008
  77:05G-009

Mathematics
  77:02F-002
  77:02G-019
  77:02G-128
  77:04B-010
  77:05B-008

Measurement
  77:02D-003
  77:02F-036
  77:02G-034
  77:02J-011
  77:03F-089
  77:04A-011
  77:04D-005
  77:05A-003
  77:05A-010
  77:07B-030
  77:08B-007
  77:08B-011
  77:08B-016

Mercury
  77:02G-090
  77:05A-006

Mesquite
  77:02D-007

Meteorological Data
  77:02D-001
  77:02D-005
  77:02D-008

Methodology
  77:02F-003
  77:02G-047
  77:02J-015
  77:03F-001
  77:03F-005
  77:04B-003
  77:04B-004
  77:04B-012
  77:07B-002

Methods
  77:05A-010

Mexico
  77:03F-005
  77:05B-044
  77:06E-003

Michigan
  77:02E-003

Micro Environment
  77:03F-035

Micro Organisms
  77:03F-012

Microwaves
  77:02G-034

Mineral Water
  77:02F-049

Mineralization
  77:02G-114
  77:02G-157
  77:02G-160
  77:02G-161
  77:02G-162
  77:02I-003
  77:05B-035

Mineralogy
  77:05A-006

Mining
  77:02G-137
  77:02J-036

Minnesota
  77:02J-008
  77:02J-010
  77:06B-002

Miscible Displacement
  77:02G-175

Missouri
  77:02J-043
  77:05G-031
  77:05G-032

Mist
  77:02D-010

Mixing
  77:05B-050

Model Studies
  77:02B-001
  77:02B-002
  77:02C-001
  77:02D-003
  77:02D-004
  77:02D-005
  77:02D-009
  77:02E-001
  77:02E-002
  77:02E-003
  77:02E-005
  77:02E-006
  77:02F-003
  77:02F-007
  77:02F-010
  77:02F-011
  77:02F-012
  77:02F-013
  77:02F-014
  77:02F-018
  77:02F-019
  77:02F-020
  77:02F-022
  77:02F-024
  77:02F-025
  77:02F-026
  77:02F-029
  77:02F-031
  77:02F-032
  77:02F-033
  77:02F-034
  77:02F-038
  77:02F-039
  77:02F-045
  77:02F-046
  77:02F-049
  77:02F-051
  77:02G-002
  77:02G-003
  77:02G-005
  77:02G-006
  77:02G-009
  77:02G-010
  77:02G-011
  77:02G-014
  77:02G-015
  77:02G-026
  77:02G-027
  77:02G-028
  77:02G-032
  77:02G-033
  77:02G-035
  77:02G-036
  77:02G-044
  77:02G-048
  77:02G-049
  77:02G-050
  77:02G-052
  77:02G-056
  77:02G-058
  77:02G-060
  77:02G-062

Model Studies
(cont.)
77:02G-065
77:02G-070
77:02G-074
77:02G-075
77:02G-080
77:02G-095
77:02G-096
77:02G-101
77:02G-123
77:02G-124
77:02G-125
77:02G-127
77:02G-128
77:02G-129
77:02G-131
77:02G-137
77:02G-138
77:02G-139
77:02G-142
77:02G-143
77:02G-175
77:02I-003
77:02I-015
77:02J-004
77:02J-007
77:02J-011
77:02J-013
77:02J-014
77:02J-015
77:02J-016
77:02J-019
77:02J-020
77:02J-029
77:02J-038
77:02J-039
77:02J-045
77:02K-003
77:03C-002
77:03F-008
77:03F-013
77:03F-038
77:03F-040
77:03F-043
77:03F-060
77:03F-072
77:03F-086
77:03F-088
77:03F-096
77:03F-129
77:03F-132
77:03F-136
77:04A-007
77:04A-009
77:04A-017
77:04A-018
77:04A-019
77:04A-023
77:04D-003
77:04D-004
77:04D-006
77:04D-007
77:05A-009
77:05B-001
77:05B-004
77:05B-008
77:05B-013
77:05B-016
77:05B-021
77:05B-022
77:05B-027
77:05B-029
77:05B-038
77:05B-040
77:05B-047
77:05B-052
77:05B-054
77:05D-008
77:05G-001
77:05G-006
77:05G-007
77:05G-008
77:05G-009
77:05G-019
77:05G-022
77:05G-027
77:05G-029
77:05G-031
77:05G-036
77:05G-039
77:06A-002
77:06A-006
77:07B-009
77:07B-010
77:07B-027
77:08B-009

Moisture Content
77:02C-001
77:02G-010
77:02G-011
77:02G-017
77:02G-027
77:02G-033
77:02G-047
77:02G-049
77:02G-060
77:02G-081
77:02G-082
77:02G-127
77:02G-175
77:03C-002
77:04A-023

Moisture Deficit
77:02G-096
77:02I-010
77:02I-011
77:03F-006

Moisture Stress
77:02G-008
77:02I-001
77:02I-010
77:02I-011
77:02L-001

Moisture Tension
77:02D-004
77:02G-008
77:02G-016

Moisture Uptake
77:03F-004
77:03F-006

Mole Drainage
77:02G-071
77:02G-092

Molybdenum
77:02G-112

Monitoring
77:02G-034
77:05A-007
77:05B-020
77:05B-026
77:05B-045
77:05G-017
77:07B-002

Montana
77:03F-043

Monte Carlo Method
77:02G-017

Monthly
77:02D-001

Montmorillonite
77:02G-004
77:02G-064
77:02G-067
77:02G-080
77:02G-121
77:02G-130
77:02G-131
77:02J-010

Moody Resistance Diagram
77:08B-013

Movement
77:05B-004
77:05B-050

Mulches
77:02J-023
77:03F-033

Mulching
77:02G-050
77:03F-020
77:03F-087
77:03F-128
77:05B-039

Multiple Purpose
77:05D-003

Municipal Wastes
77:05E-002

Municipal Water
77:06E-008
77:06E-011
77:06E-012

Natural Resources
77:02F-044
77:03F-027

Nebraska
77:02D-001
77:02D-011
77:02E-004
77:02F-027
77:02F-042

Nebraska
(cont.)
77:02F-044
77:02G-096
77:03F-020
77:03F-084
77:03F-117
77:04B-015
77:07B-035
77:05D-009
77:05G-004
77:05G-026
77:07B-015
77:07B-020
77:07B-035

Nematocides
77:03F-080

Networks
77:03F-005
77:04B-003

Nevada
77:05B-037

New Jersey
77:06E-008

New Mexico
77:02F-040
77:02F-049
77:03F-106
77:03F-107
77:05B-005

Nitrates
77:02G-036
77:02G-037
77:02G-038
77:02G-040
77:02G-063
77:02G-096
77:02G-097
77:02G-103
77:02G-105
77:02G-113
77:02G-120
77:02G-147
77:02G-165
77:02I-012
77:02K-005
77:03F-049
77:03F-057
77:04B-013
77:05A-002
77:05A-004
77:05A-007
77:05A-009
77:05B-004
77:05B-005
77:05B-010
77:05B-011
77:05B-016
77:05B-017
77:05B-020
77:05B-024
77:05B-025
77:05B-031
77:05B-039
77:05B-042
77:05B-048
77:05B-050
77:05B-053
77:05B-055
77:05D-007

Nitrification
77:02G-036
77:02G-053
77:02G-062
77:02G-103
77:02G-160
77:02G-169
77:02I-003
77:02K-005
77:05A-010
77:05B-036
77:05B-051
77:05D-002
77:05D-005
77:05E-002
77:07B-032

Nitrites
77:02G-097
77:02G-113
77:02G-159
77:02G-163
77:05B-025
77:05B-048
77:07B-034

Nitrogen
77:02B-001
77:02G-040
77:02G-041
77:02G-053
77:02G-063
77:02G-096
77:02G-099
77:02G-100
77:02G-103
77:02G-104
77:02G-113
77:02G-114
77:02G-120
77:02G-143
77:02G-146
77:02G-147
77:02G-159
77:02G-160
77:02G-161
77:02G-162
77:02G-163
77:02G-165
77:02G-169
77:02G-170
77:02G-171
77:02I-003
77:02I-012
77:02J-008
77:02J-011
77:02J-044
77:02J-046
77:02K-005
77:03F-004
77:03F-014
77:03F-032
77:03F-043
77:03F-045
77:03F-049
77:03F-056
77:03F-090
77:03F-108
77:03F-109
77:03F-127
77:03F-131
77:05A-002
77:05A-010
77:05B-014
77:05B-026
77:05B-029
77:05B-030
77:05B-031
77:05B-033
77:05B-035
77:05B-036
77:05B-038
77:05B-039
77:05B-043
77:05B-048
77:05B-050
77:05B-053
77:05B-055
77:05C-005
77:05D-008
77:05G-004
77:05G-005
77:05G-019
77:05G-031
77:07B-003
77:07B-010
77:07B-014
77:07B-016
77:07B-020
77:07B-032
77:07B-033

Nitrogen Compounds
77:04B-015
77:05A-010
77:05B-048
77:05G-004

Nonhomogeneous Soils
77:02G-125

Nonpoint Source Pollution
77:05G:023
77:05G-040

North Dakota
77:02G-005
77:02I-018
77:03F-058

Nuclear Meters
77:02G-047

Nuclear Moisture Meters
77:02D-003
77:02G-047

Nuclear Powerplants
77:05B-022

Nuclear Reactors
77:05B-007

Nuclear Wastes
77:05B-007

Numerical Analysis
77:02F-001
77:02F-009
77:02F-010
77:02F-012
77:02F-014
77:02F-028
77:02F-029
77:02G-027
77:02G-077
77:02J-015

Nutrient Removal
77:02G-143

Nutrient Requirements
77:03F-004

Nutrients
77:02E-003
77:02G-053
77:02G-057
77:02G-062
77:02G-101
77:02G-104
77:02G-134
77:02G-143
77:02G-147
77:02G-149
77:02G-150
77:02G-157
77:02G-163
77:02G-170
77:02G-171
77:02I-012
77:02J-008
77:02J-010
77:02J-044
77:02J-046
77:03F-013
77:03F-014
77:03F-022
77:03F-032
77:03F-033
77:03F-045
77:03F-047
77:03F-049
77:03F-062
77:03F-090
77:03F-102
77:03F-108
77:03F-109
77:03F-116
77:03F-127
77:03F-129
77:03F-130
77:03F-132
77:04A-006
77:04A-042
77:05B-011
77:05B-014
77:05B-026
77:05B-029
77:05B-030
77:05B-032
77:05B-046
77:05B-048
77:05B-055
77:05D-007
77:05G-004
77:05G-015
77:05G-019
77:05G-023
77:05G-027
77:05G-031
77:05G-033
77:05G-040
77:07B-002
77:07B-014
77:07B-015
77:07B-018

Oak Trees
77:02G-014

Oats
77:02I-010
77:02I-011
77:02J-023
77:04D-005

Observation Wells
77:02F-037
77:02G-025
77:04B-007
77:05B-019

Ohio
77:02B-001
77:04B-012
77:04D-005
77:05B-049

Oklahoma
77:02G-114

On-Site Data Collections
77:03F-089
77:05B-017
77:05B-031

On-Site Investigations
77:02E-004
77:02F-036
77:02G-003
77:02G-005
77:02G-006
77:02G-007
77:02G-014
77:02G-015
77:02G-017
77:02G-018
77:02G-031
77:02G-050
77:02G-060
77:02G-082
77:02G-174
77:02I-011
77:02J-011
77:02K-001
77:04D-001
77:04D-005
77:05B-002
77:05B-003
77:05B-005
77:05B-018
77:05B-022
77:05B-045
77:05B-050
77:08B-007

On-Site Tests
77:02D-002
77:02D-003
77:02D-005
77:02G-125
77:02J-011
77:02J-041
77:04D-005
77:05B-050
77:07B-001

Onions
77:03F-042
77:03F-079

Open Channel Flow
77:02E-001
77:07B-025
77:07B-026
77:07B-027
77:07B-029
77:08B-001
77:08B-003

Open Channels
77:02J-007
77:04D-007
77:05A-001
77:07B-026
77:08B-001

Operations
77:03F-003
77:03F-021

Operations Research
77:04B-004
77:05G-003

Optimization
77:02F-039
77:02G-019
77:03C-002
77:03F-001
77:03F-003
77:03F-088
77:04A-001
77:04B-001
77:04B-003
77:04B-004
77:04B-006
77:04B-008
77:05D-003
77:05G-003
77:05G-018
77:08B-004

Orchards
77:02G-049
77:03F-086
77:03F-121
77:04A-008
77:04A-026

Oregon
77:02G-082
77:06E-013

Organic Compounds
77:02G-156

Organic Loadings
77:05B-026

Organic Material
77:02F-030

Organic Matter
77:02G-082
77:02G-089
77:02G-090
77:02G-119
77:02G-157
77:02G-172
77:03F-012
77:03F-030
77:03F-128
77:05D-002

Orifice Flow
77:03F-089

Orifices
77:03F-089
77:04A-028
77:08B-005
77:08B-008

Osmotic Pressure
77:02G-008

Overflow
77:08B-011

Overland Flow
77:02E-005
77:02G-142
77:02J-042
77:02J-044

Oxidation
77:02G-085
77:02G-158
77:02G-159
77:05B-051

Oxidation-Reduction Potential
77:05A-006

Particle Size
77:02F-005
77:02G-016
77:05B-049
77:05B-051

Pasture Management
77:03F-015
77:03F-016

Pastures
77:02G-071
77:03F-015
77:03F-016
77:05A-003

Path of Pollutants
77:02G-015
77:02G-018
77:02G-022
77:02G-143
77:05B-001
77:05B-002
77:05B-004
77:05B-008
77:05B-009
77:05B-021
77:05B-024
77:05B-025
77:05B-027
77:05B-056
77:05G-032

Peaches
77:02D-010
77:03F-086

Peak Discharge
77:04D-006

Peanuts
77:03F-039
77:03F-044

Pennsylvania
77:02K-002
77:05B-050

Perched Water
77:02G-025

Percolation
77:02B-002
77:02F-001
77:02G-003
77:02G-078
77:02G-096
77:02G-142
77:05B-004
77:05B-010
77:05B-050
77:05G-004

Perlite
77:02G-008

Permability
77:02B-002
77:02F-005
77:02F-006
77:02F-007
77:02F-009
77:02F-014
77:02F-015
77:02F-019
77:02F-020
77:02F-033
77:02F-034
77:02F-036
77:02F-047
77:02F-049
77:02G-004
77:02G-030
77:02G-095
77:02G-142
77:02G-174

Permits
77:05G-021

Permselective Membranes
77:05A-009

Pesticide Removal
77:05G-002

Pesticide Residues
77:05B-006

Pesticides
77:02E-003
77:02G-175
77:03F-116
77:04A-042
77:05B-006
77:05B-009
77:05B-011
77:05B-041
77:05B-046
77:05B-056
77:05G-002
77:05G-011
77:05G-023
77:05G-024
77:05G-040

Petrology
77:02K-002

Phosphates
77:02G-059
77:02G-084
77:02G-132
77:02G-135
77:02G-164
77:03F-057
77:04A-006
77:05A-003
77:05A-004
77:05B-001
77:05B-011
77:05B-025
77:05D-004
77:05D-006
77:05D-009

Phosphorus
77:02B-001
77:02G-052
77:02G-059
77:02G-099
77:02G-109
77:02G-110
77:02G-143
77:02G-149
77:02G-150
77:02G-151
77:02J-008
77:02J-011
77:02J-044
77:02J-046
77:03F-004
77:03F-022
77:03F-031
77:04B-014
77:05A-003

Phosphorus
(cont.)
77:05B-001
77:05B-026
77:05B-027
77:05B-028
77:05B-029
77:05B-030
77:05B-037
77:05C-003
77:05D-005
77:05G-031
77:05G-033
77:07B-013
77:07B-014
77:07B-018

Phosphorus Compounds
77:05B-001

Photoperiodism
77:02I-001

Photosynthesis
77:02D-002
77:02I-010
77:03F-006
77:03F-055
77:07B-014

Physical Properties
77:02G-056
77:02G-078
77:02G-173
77:02I-040
77:05B-007
77:05G-033

Phytoplankton
77:05B-009

Piezometers
77:04D-001

Pine Trees
77:02G-014

Pipe Flow
77:07B-029
77:08B-002
77:08B-009
77:08B-013

Pipelines
77:04A-024
77:07B-029
77:08B-013

Pipes
77:04A-024
77:08B-009
77:08B-013

Piping Systems
77:04A-024

Pit Recharge
77:05A-007

Planning
77:02J-013
77:04B-006
77:04B-008
77:05D-003
77:06A-005
77:06B-001
77:06B-002

Plant Growth
77:02D-011
77:02I-001
77:02I-010
77:02I-011
77:02I-017
77:03C-002
77:03F-006
77:03F-087
77:03F-112

Plant Morphology
77:02I-002

Plant Physiology
77:02D-009
77:02I-010
77:02I-011
77:02I-017
77:03F-006
77:03F-055
77:05B-056

Planting Management
77:02I-010
77:02I-011

Plants
77:03F-106

Plastic Pipes
77:07B-002
77:08B-008

Plumbing
77:05A-006

Plutonium
77:02G-102

Political Aspects
77:02J-027

Political Constraints
77:03F-135

Pollutant Identification
77:05A-001
77:05A-002
77:05A-003
77:05A-009
77:05B-006
77:05G-023
77:05G-038

Pollutants
77:02E-004
77:03F-066
77:05B-001
77:05B-004
77:05B-006
77:05B-008
77:05B-009
77:05B-021
77:05B-024
77:05B-027
77:05B-031
77:05B-037
77:05B-045
77:05B-048
77:05B-056
77:05D-009
77:05G-002
77:05G-004
77:05G-023

Pollution
77:02G-036
77:02J-011
77:02J-014
77:02J-045
77:03F-066
77:05B-021
77:05G-015
77:05G-039
77:06A-002
77:07B-017

Pollution Abatement
77:05G-021
77:05G-023

Pollution Control
77:02G-036

Pollution Taxes
77:05G-023

Ponding
77:02B-002
77:02G-058
77:02G-127

Population
77:06D-002

Pore Pressure
77:02F-031
77:02G-011
77:02G-080

Pore Water
77:02F-014
77:02G-018

Pores
77:02F-033
77:02G-080

Porosity
77:02F-005
77:02F-012
77:02F-033
77:02F-047
77:02G-080
77:02G-143
77:05G-001

Porous Media
77:02C-001
77:02F-002
77:02F-007
77:02F-009
77:02F-012
77:02F-014
77:02F-024
77:02F-033
77:02F-034
77:02F-052
77:02G-002
77:02G-012
77:02G-013
77:02G-016
77:02G-018
77:02G-030
77:02G-033
77:02G-061
77:02G-094
77:02G-124
77:02G-127
77:02G-143

Potassium
77:02B-001
77:02G-066
77:02G-145
77:02G-148
77:02J-008
77:03F-032
77:04B-009
77:05B-011
77:05B-049

Potatoes
77:03F-045
77:03F-056
77:05B-017
77:05G-005

Potentiometric Level
77:02F-006

Powerplants
77:04A-041
77:05B-022

Precipitation (atmospheric)
77:02B-002
77:02E-004
77:02F-011
77:02G-032
77:02G-034
77:02G-050
77:02G-060
77:02G-127
77:02G-142
77:02J-044
77:05B-021

Precipitation Excess
77:02B-002

Precipitation Intensity
77:02B-002

Pressure
77:02D-008
77:02G-002
77:02G-004
77:02G-011
77:02G-035
77:08B-003

Pressure Head
77:02G-033
77:02G-035
77:02G-058
77:02G-126
77:02G-175
77:02G-176

Prices
77:03F-001

Pricing
77:03F-073
77:03F-074
77:03F-135
77:05G-003

Priorities
77:06B-002

Probability
77:04B-004

Profiles
77:02D-003
77:02G-010
77:02G-027
77:02G-033
77:08B-003

Project Feasibility
77:03F-001

Project Planning
77:03F-001

Projects
77:06C-001

Properties
77:02G-078

Public Benefits
77:06B-001

Public Health
77:05B-031

Public Rights
77:06A-005

Pump Testing
77:02F-036
77:02F-051

Pumping
77:02F-013
77:02F-019
77:02F-023
77:02F-025
77:02F-028
77:02F-037
77:02F-047
77:02F-048
77:03F-021
77:03F-106
77:03F-107
77:03F-113
77:04A-001
77:04A-041
77:04B-001
77:04B-004
77:04B-005
77:04B-006
77:04B-007
77:04B-012
77:04B-015
77:05B-020
77:05G-017

Pumping Plants
77:02F-051
77:03F-070
77:03F-107
77:04A-041
77:08C-001

Pumping Recharge
77:04B-003

Pumps
77:02F-051
77:03F-106
77:03F-107
77:08C-001

Radiation
77:02D-008

Radioactive Wastes
77:05B-007

Radiochemical Analysis
77:05B-007

Radioisotopes
77:02G-054
77:05B-007

Raindrops
77:02G-079
77:02J-001

Rainfall
77:02B-002
77:02D-008
77:02F-023
77:02F-049
77:02G-034
77:02G-050
77:02G-058
77:02G-060
77:02G-071
77:02G-075
77:02G-096
77:02G-127
77:02G-137
77:02G-142
77:02J-001
77:02J-008
77:02J-015
77:02J-023
77:02J-025
77:02J-042
77:02J-044

Rainfall
(cont.)
77:03F-003
77:03F-109
77:04D-005
77:05B-033
77:05B-052
77:07B-011

Rainfall Intensity
77:02B-001
77:02G-050
77:02G-075

Rainfall Patterns
77:02B-002

Rain-Runoff Relationships
77:02G-032
77:02G-075
77:02G-095
77:02J-008

Rainfall Simulators
77:02J-001
77:07B-011

Range Grasses
77:02E-005

Rating Curves
77:08B-016

Recharge
77:02F-011
77:02F-025
77:02F-032
77:02F-040
77:02F-049
77:04B-012
77:05D-004
77:05D-005

Recharge Ponds
77:05A-007

Recycling
77:04A-005
77:05D-001

Reflectance Analysis
77:02D-002

Regional Analysis
77:04A-022
77:04B-003

Regions
77:03F-018
77:05D-003
77:06C-001

Regression Analysis
77:02G-036
77:02G-056
77:02G-173
77:03B-001
77:03F-005
77:04B-005

Regulation
77:05G-021

Remote Sensing
77:02G-034

Research and Development
77:03F-007

Reservoir Design
77:04D-006

Reservoir Silting
77:02J-015

Reservoir Storage
77:02J-015

Reservoirs
77:02J-015
77:04A-022
77:04B-003
77:05G-031
77:05G-032
77:05G-033

Resistivity
77:02F-005
77:02F-021
77:02F-036

Resource Development
77:03F-077

Resources
77:02F-044
77:03F-077

Respiration
77:02G-158

Retention
77:02G-032
77:02G-081

Return Flow
77:02G-038
77:02G-039
77:02G-044
77:02G-103
77:02I-004
77:02J-010
77:03A-001
77:03F-007
77:03F-008
77:03F-057
77:04A-004
77:04A-005
77:04A-006
77:04A-008
77:04A-009
77:04A-010
77:04A-029
77:04A-030
77:04A-042
77:05A-004
77:05A-005
77:05B-003
77:05B-011
77:05B-012
77:05B-013
77:05B-017
77:05B-037
77:05G-005
77:05G-008
77:05G-010
77:05G-011
77:05G-019
77:05G-020
77:05G-022
77:05G-027
77:05G-028
77:05G-030
77:05G-034
77:06A-001
77:06A-003
77:06A-006
77:06E-002
77:06E-004
77:06E-006
77:07B-010

Return (Monetary)
77:03F-001

Reviews
77:02J-004

Reynolds Number
77:02G-030

Rhodamine
77:07B-001

Rhode Island
77:02F-036

Rice
77:02G-008
77:02G-099
77:02G-109
77:02I-019
77:03F-002
77:03F-046
77:05B-006
77:05B-011
77:05C-004

Rill Erosion
77:02J-041
77:02J-042

Rio Grande River
77:04A-008

Risks
77:02J-015
77:03F-001

River Basins
77:04A-001
77:04A-022
77:04B-012
77:05D-003
77:05G-003
77:05G-023

Rivers
77:02E-001
77:02J-043
77:05B-002
77:05G-001

Rock Properties
  77:02F-021
  77:02K-002

Rocks
  77:02K-002

Root Development
  77:02G-070
  77:02I-002
  77:02I-011
  77:02I-014
  77:02I-015
  77:03F-046
  77:03F-099

Root Distribution
  77:02G-070
  77:02I-011

Root Systems
  77:02D-009
  77:02G-070
  77:02G-156
  77:02G-166
  77:02I-002
  77:02I-005
  77:02I-014
  77:02I-015
  77:03F-011
  77:03F-015
  77:03F-016
  77:03F-046

Root Zone
  77:02G-141
  77:02I-002
  77:02I-014
  77:03C-002
  77:03F-004
  77:04A-008
  77:04B-009
  77:05G-001
  77:05G-034

Roots
  77:02J-005
  77:04B-013

Rotational Flow
  77:03F-002
  77:04D-007

Roughness Coefficient
  77:02D-006

Runoff
  77:02B-001
  77:02B-002
  77:02D-007
  77:02E-002
  77:02E-003
  77:02E-004
  77:02E-005
  77:02F-041
  77:02G-036
  77:02G-058
  77:02G-071
  77:02G-093
  77:02G-095
  77:02G-127
  77:02G-142
  77:02J-001
  77:02J-008
  77:02J-010
  77:02J-017
  77:02J-022
  77:02J-023
  77:02J-041
  77:02J-042
  77:02J-043
  77:02J-044
  77:02J-046
  77:03F-020
  77:03F-024
  77:03F-048
  77:03F-062
  77:03F-110
  77:03F-116
  77:04A-006
  77:04A-037
  77:04A-042
  77:04D-005
  77:04D-006
  77:05B-009
  77:05B-027
  77:05B-029
  77:05B-046
  77:05B-048
  77:05B-054
  77:05G-004
  77:05G-022
  77:05G-023
  77:05G-024
  77:05G-031
  77:05G-040
  77:07B-011
  77:07C-002

Rural Area
  77:03F-017

Sago Pondweed
  77:02I-018

Saline Soils
  77:02G-015
  77:02G-078
  77:02G-083
  77:02G-160
  77:02I-006
  77:03C-001
  77:03F-120
  77:04A-002
  77:04A-003
  77:04A-008
  77:04A-026
  77:05A-008
  77:05B-013
  77:05B-015
  77:05G-001
  77:05G-016
  77:07B-006

Saline Water
  77:02F-024
  77:02G-042
  77:02G-078
  77:02I-004
  77:02I-006
  77:02I-008
  77:02I-018
  77:03C-001
  77:03C-002
  77:03F-067
  77:04A-002
  77:05A-008
  77:05B-013
  77:05B-044
  77:05C-002
  77:05E-001
  77:05G-017
  77:05G-037

Saline Water Intrusion
  77:02F-028
  77:02F-040
  77:04B-011

Saline-Freshwater Interfaces
  77:02F-020
  77:02F-028

Salinity
  77:02F-005
  77:02G-015
  77:02G-042
  77:02G-043
  77:02G-044
  77:02G-077
  77:02G-078
  77:02G-083
  77:02G-145
  77:02G-160
  77:02G-176
  77:02I-004
  77:02I-006
  77:02I-008
  77:03C-001
  77:03C-002
  77:03F-033
  77:03F-057
  77:03F-067
  77:03F-120
  77:03F-126
  77:04A-002
  77:04A-021
  77:04A-026
  77:04A-029
  77:04B-009
  77:04B-011
  77:05A-005
  77:05A-007
  77:05A-008
  77:05B-003
  77:05B-013
  77:05B-015
  77:05B-018
  77:05B-021
  77:05B-028
  77:05B-044
  77:05C-001
  77:05C-002
  77:05G-001
  77:05G-003
  77:05G-013

Salinity
(cont.)
77:05G-014
77:05G-015
77:05G-016
77:05G-018
77:05G-019
77:05G-022
77:05G-027
77:05G-037
77:06A-006
77:06E-003
77:07B-006
77:09C-001

Salt Balance
77:04A-001

Salt Tolerance
77:02I-006
77:03C-001
77:05B-028
77:05G-035

Salts
77:02D-004
77:02G-004
77:02G-015
77:02G-078
77:02G-083
77:02G-155
77:02G-160
77:02G-175
77:02G-176
77:02I-006
77:02I-008
77:03C-001
77:03F-116
77:04A-026
77:04A-029
77:04A-030
77:05A-005
77:05A-007
77:05A-008
77:05B-015
77:05B-021
77:05B-028
77:05B-039
77:05G-034
77:05G-037

Sampling
77:02G-001
77:02G-003
77:02G-017
77:02G-038
77:02G-040
77:02G-054
77:02G-068
77:02G-158
77:02I-017
77:02I-018
77:02J-002
77:02J-011
77:03F-010
77:03F-011
77:03F-059
77:05A-007
77:05B-017
77:05B-020
77:05B-031
77:05B-034
77:05B-050
77:05B-055
77:05G-033
77:07B-005
77:07B-008
77:07B-012
77:07B-013
77:07B-018
77:07B-019
77:07B-020
77:07B-021
77:07B-023
77:07B-031
77:07B-032
77:07B-033
77:07B-035
77:07B-036
77:08A-001
77:08B-004

Sand Aquifers
77:02F-005

Sands
77:02G-022
77:02G-027
77:02G-096
77:02G-167
77:02J-002
77:03F-056
77:05B-001
77:05B-010
77:05D-004

Sandstones
77:02F-005
77:02F-021
77:02F-025

Satellites (Artificial
77:02G-034
77:02L-001

Saturated Flow
77:02F-004
77:02F-014
77:02G-016
77:02G-022
77:02G-023
77:02G-094
77:02G-128
77:04A-025
77:08B-008

Saturated Soils
77:02G-113
77:02G-127
77:02I-019
77:03F-046
77:05C-004

Saturation
77:02G-058
77:02I-018

Scaling
77:02G-031

Scheduling
77:03F-050
77:03F-082
77:03F-117
77:07B-036

Scour
77:02J-043

Screens
77:02F-019

Sea Water
77:02F-028
77:04B-011

Seasonal
77:03B-001
77:04B-004
77:05B-020

Sediment Control
77:02J-012
77:02J-019
77:02J-035
77:02J-036
77:02J-039
77:04A-042
77:04D-007
77:06A-001
77:08B-005

Sediment Discharge
77:02J-012
77:02J-013
77:02J-015
77:02J-029
77:02J-030
77:02J-037

Sediment Load
77:02J-011
77:02J-012
77:02J-018
77:02J-019
77:02J-025
77:02J-026
77:02J-029
77:02J-030
77:02J-039
77:03F-063
77:04A-035
77:04D-004

Sediment Transport
77:02J-001
77:02J-002
77:02J-004
77:02J-011
77:02J-012
77:02J-013
77:02J-016
77:02J-025
77:02J-028
77:02J-029
77:02J-031
77:02J-032
77:02J-034
77:02J-039
77:02J-040
77:02J-042

Sediment Transport
(cont.)
77:04D-004
77:04D-007
77:05B-049

Sediment Yield
77:02J-004
77:02J-015
77:02J-017
77:02J-041
77:02J-042
77:04A-006
77:04D-005
77:04D-006

Sediment-Water Interfaces
77:02I-018

Sedimentary Basins
77:02J-018

Sedimentary Rocks
77:02K-002

Sedimentation
77:02J-002
77:02J-003
77:02J-004
77:02J-007
77:02J-011
77:02J-012
77:02J-013
77:02J-018
77:02J-019
77:02J-024
77:02J-028
77:02J-030
77:02J-045
77:04A-042
77:04D-001
77:04D-004
77:05B-033
77:05B-046
77:05B-053
77:05B-054
77:05C-003
77:05G-022
77:05G-024
77:05G-031
77:06E-007
77:07B-011
77:08B-005

Sediments
77:02E-003
77:02G-071
77:02G-149
77:02I-018
77:02I-019
77:02J-002
77:02J-003
77:02J-010
77:02J-011
77:02J-012
77:02J-014
77:02J-017
77:02J-018
77:02J-024
77:02J-025
77:02J-026
77:02J-027
77:02J-029
77:02J-030
77:02J-035
77:02J-036
77:02J-037
77:02J-038
77:02J-039
77:02J-044
77:02J-045
77:03F-062
77:03F-063
77:03F-116
77:04A-006
77:04A-042
77:04D-004
77:04D-007
77:05A-004
77:05B-007
77:05B-009
77:05B-030
77:05B-033
77:05B-048
77:05B-049
77:05B-053
77:05B-054
77:05C-003
77:05G-002
77:05G-025
77:05G-031
77:05G-032
77:05G-033
77:07B-002
77:07B-011

Sedimentology
77:02J-002
77:02J-013

Seed Treatment
77:03C-001

Seeds
77:03C-001
77:03F-085

Seepage
77:02F-001
77:02F-009
77:02F-015
77:02F-052
77:02G-003
77:02G-021
77:02G-048
77:02G-054
77:02G-124
77:02G-143
77:02I-008
77:03F-063
77:03F-095
77:04A-015
77:05A-005
77:05G-007
77:05G-036
77:07B-024
77:09C-001

Seepage Control
77:02G-124
77:05G-036

Semiarid Climates
77:03C-001
77:06D-002

Settling Basins
77:08B-005

Settling Velocity
77:08B-005

Sewage Disposal
77:05G-017

Sewage Sludge
77:05B-045

Sewage Treatment
77:05D-008
77:05E-002

Shallow Wells
77:05B-020

Shape
77:02F-008

Shear Strength
77:02G-079

Shear Stress
77:02J-003
77:02J-042
77:08B-001

Sheet Erosion
77:02G-007
77:02J-001
77:02J-041
77:02J-042

Silts
77:02G-082
77:02J-003
77:02J-010
77:02J-044

Silviculture
77:02G-153

Simulated Analysis
77:02E-002
77:02E-051
77:02G-010
77:02G-027
77:02G-044
77:02G-052
77:02G-076
77:02G-094
77:02G-123
77:02G-137
77:02I-003
77:02I-015
77:02J-007
77:02J-016
77:02J-017
77:02J-019
77:02J-031

Simulated Analysis
(cont.)
77:03F-003
77:03F-072
77:03F-088
77:03F-096
77:03F-129
77:04A-001
77:04A-007
77:04A-017
77:04A-019
77:04B-002
77:04B-008
77:04B-012
77:05B-013
77:05B-029
77:05B-040
77:05B-052
77:05G-006
77:05G-008
77:05G-009
77:05G-019
77:05G-028
77:05G-029
77:05G-031
77:07B-009
77:07B-010
77:07B-011
77:08B-009

Simulated Rainfall
77:02B-001
77:02G-058
77:02J-001
77:02J-044

Sinks
77:02F-010

Slope Stability
77:04D-001

Slopes
77:02B-001
77:02F-008
77:02J-001
77:02J-041
77:02J-043

Sludge
77:05E-002

Sludge Disposal
77:05B-045

Sluice Gates
77:08B-003

Sluices
77:08B-003

Small Watersheds
77:02E-005

Snowmelt
77:02J-008

Social Aspects
77:02J-027

Social Needs
77:06B-001

Social Participation
77:06B-001

Social Values
77:02J-027

Sodium
77:02F-016
77:02G-066
77:02G-080
77:02G-081
77:02G-107
77:02G-108
77:02G-121
77:02J-008
77:04B-009
77:05B-005
77:05B-049
77:05G-037

Sodium Chloride
77:02G-004
77:03C-001
77:05B-019

Soil Aggregates
77:02G-012
77:02G-013

Soil Amendments
77:02G-046
77:02G-154
77:02G-160
77:02G-161
77:02G-162
77:02G-168
77:05B-045
77:05E-002

Soil Analysis
77:02G-047
77:03C-002
77:05B-006
77:05B-009
77:05B-048
77:05B-049

Soil Chemical Properties
77:02G-015
77:02G-067
77:02G-069
77:02G-078
77:02G-098
77:02G-106
77:02G-110
77:02G-111
77:02G-112
77:02G-164
77:02G-165
77:02G-169
77:03F-015
77:03F-016
77:05G-001

Soil Chemistry
77:02G-069
77:02G-084
77:02G-085
77:02G-089
77:02G-090
77:02G-098
77:02G-101
77:02G-102
77:02G-105
77:02G-106
77:02G-107
77:02G-110
77:02G-111
77:02G-112
77:02G-121
77:02G-130
77:02G-131
77:02G-132
77:02G-133
77:02G-134
77:02G-135
77:02G-145
77:02G-146
77:02G-148
77:02G-150
77:02G-151
77:02G-155
77:02G-157
77:02G-158
77:02G-161
77:02G-162
77:02G-163
77:02G-164
77:02G-165
77:02G-169
77:02G-170
77:02K-001
77:02K-003
77:03F-015
77:03F-016
77:03F-132
77:05B-001
77:05B-023
77:05B-049
77:05G-004
77:05G-029
77:06A-006

Soil Compaction
77:02G-136
77:03F-110

Soil Conservation
77:02J-034
77:03F-020
77:03F-051
77:03F-052
77:03F-066
77:04A-042
77:05B-030

Soil Contamination
77:02B-001
77:05B-006
77:05B-008
77:05B-009
77:05B-024
77:05B-045
77:05B-056

Soil Density
77:02G-161
77:02G-162
77:03F-110

Soil Environment
77:02J-008
77:03F-099
77:07B-008

Soil Erosion
77:02B-001
77:02G-173
77:02J-001
77:02J-008
77:02J-010
77:02J-012
77:02J-016
77:02J-017
77:02J-020
77:02J-022
77:02J-023
77:02J-025
77:02J-027
77:02J-028
77:02J-029
77:02J-030
77:02J-031
77:02J-032
77:02J-033
77:02J-034
77:02J-035
77:02J-037
77:02J-038
77:02J-040
77:02J-041
77:02J-042
77:02J-044
77:02J-046
77:03F-048
77:03F-051
77:03F-052
77:03F-110
77:05B-030
77:05G-025
77:06E-007
77:07B-011

Soil Filters
77:05D-004
77:05D-005

Soil Gases
77:07B-016

Soil Horizons
77:02G-032

Soil Investigations
77:02G-005
77:02G-036
77:02G-038
77:02G-039
77:02G-041
77:02G-043
77:02G-051
77:02G-052
77:02G-057
77:02G-059
77:02G-062
77:02G-063
77:02G-066
77:02G-068
77:02G-069
77:02G-070
77:02G-071
77:02G-076
77:02G-084
77:02G-085
77:02G-089
77:02G-090
77:02G-097
77:02G-098
77:02G-099
77:02G-100
77:02G-102
77:02G-105
77:02G-106
77:02G-107
77:02G-108
77:02G-109
77:02G-110
77:02G-111
77:02G-112
77:02G-113
77:02G-114
77:02G-119
77:02G-120
77:02G-121
77:02G-133
77:02G-144
77:02G-145
77:02G-146
77:02G-147
77:02G-148
77:02G-149
77:02G-151
77:02G-152
77:02G-155
77:02G-157
77:02G-158
77:02G-159
77:02G-161
77:02G-162
77:02G-164
77:02G-165
77:02G-166
77:02G-167
77:02G-168
77:02G-169
77:02G-170
77:02G-171
77:02G-172
77:02J-008
77:02J-024
77:02K-003
77:03F-012
77:03F-013
77:03F-015
77:03F-016
77:03F-031
77:03F-041
77:03F-099
77:03F-111
77:03F-127
77:03F-128
77:04A-029
77:04B-014
77:05B-015
77:05B-032
77:05B-039
77:05B-043
77:05B-052
77:05C-004
77:07B-006
77:07B-008
77:07B-012
77:07B-016
77:07B-017
77:07B-019
77:07B-037

Soil Management
77:02J-008
77:03F-048
77:03F-051
77:03F-052
77:03F-110
77:05B-003
77:05B-041

Soil Mechanics
77:04D-001

Soil Microorganisms
77:02G-166

Soil Moisture
77:02D-004
77:02D-011
77:02F-031
77:02G-003
77:02G-005
77:02G-006
77:02G-008
77:02G-009
77:02G-010
77:02G-030
77:02G-033
77:02G-034
77:02G-035
77:02G-039
77:02G-047
77:02G-054
77:02G-055
77:02G-071
77:02G-074
77:02G-078
77:02G-087
77:02G-088
77:02G-091
77:02G-114
77:02G-115
77:02G-129
77:02G-136
77:02G-142
77:02G-146
77:02G-148
77:02G-151
77:02G-152
77:02G-155
77:02G-156
77:02G-170
77:02I-002
77:02I-005
77:02I-007
77:02I-008
77:02I-014
77:02I-015
77:02I-016

Soil Moisture
(cont.)
77:03C-002
77:03F-003
77:03F-020
77:03F-023
77:03F-028
77:03F-036
77:03F-042
77:03F-044
77:03F-046
77:03F-050
77:03F-054
77:03F-069
77:03F-075
77:03F-078
77:03F-082
77:03F-090
77:03F-094
77:03F-099
77:03F-109
77:03F-112
77:03F-126
77:03F-136
77:04A-026
77:04A-029
77:04D-006
77:05B-035
77:05B-041
77:06D-002
77:07B-006
77:07B-023
77:07B-036
77:07C-002

Soil Moisture Meters
77:02G-034
77:02G-047

Soil Particles
77:03F-095

Soil Physical Properties
77:02G-031
77:02G-040
77:02G-046
77:02G-074
77:02G-125
77:02G-168
77:02G-174
77:02G-176
77:03F-099
77:03F-110
77:04A-036

Soil Physics
77:02D-004
77:02G-002
77:02G-003
77:02G-006
77:02G-031
77:02G-035
77:02G-074
77:02G-127
77:02G-173
77:02G-174
77:02G-175
77:03F-132
77:04A-023
77:05B-002
77:05B-024

Soil Profiles
77:02D-004
77:02D-005
77:02G-032
77:02G-051
77:02G-120
77:02G-129
77:02G-154
77:02G-167
77:03F-015
77:03F-016
77:03F-111
77:05B-002
77:05B-003
77:05B-004
77:05B-055
77:05D-004
77:05G-040
77:07B-016
77:07B-019
77:07B-020

Soil Properties
77:02B-002
77:02D-009
77:02G-005
77:02G-010
77:02G-015
77:02G-017
77:02G-028
77:02G-032
77:02G-046
77:02G-047
77:02G-050
77:02G-055
77:02G-056
77:02G-060
77:02G-067
77:02G-069
77:02G-080
77:02G-081
77:02G-082
77:02G-083
77:02G-089
77:02G-091
77:02G-096
77:02G-099
77:02G-104
77:02G-107
77:02G-108
77:02G-109
77:02G-119
77:02G-121
77:02G-130
77:02G-131
77:02G-132
77:02G-133
77:02G-134
77:02G-140
77:02G-143
77:02G-148
77:02G-150
77:02G-157
77:02G-158
77:02G-168
77:02G-169
77:02G-172
77:02G-173
77:02G-174
77:02K-005
77:03F-043
77:03F-048
77:03F-080
77:03F-099
77:03F-100
77:03F-103
77:03F-110
77:04A-036
77:04B-014
77:05B-015
77:05B-041
77:05B-042
77:07B-008
77:07B-012
77:07B-016
77:07B-019
77:07B-023
77:07B-037

Soil Science
77:02D-004
77:02F-033
77:02G-001
77:02G-002
77:02G-003
77:02G-004
77:02G-005
77:02G-006
77:02G-015
77:02G-016
77:02G-017
77:02G-018
77:02G-022
77:02G-023
77:02G-024
77:02G-027
77:02G-035
77:02G-056
77:02G-058
77:02G-074
77:02G-080
77:02G-083
77:02G-127
77:02G-174
77:02G-175
77:02J-001
77:02J-008
77:04A-023
77:05B-002
77:05B-056

Soil Solutions
77:02G-083

Soil Strength
77:02G-079
77:04D-001

Soil Structure
77:02G-023
77:02G-024
77:03F-110
77:03F-111

Soil Surface
77:03F-048

Soil Temperature
77:02G-005
77:02G-006
77:02G-007
77:02G-051
77:02G-104
77:02G-140
77:03F-041
77:03F-055

Soil Tests
77:02G-047
77:02G-068
77:02G-089
77:02G-097
77:02G-107
77:02G-126
77:02G-158
77:03F-111
77:07B-008
77:07B-019
77:07B-020
77:07B-037

Soil Texture
77:02G-104
77:02G-110
77:02G-119
77:02G-161
77:02G-162
77:02G-167
77:02G-171
77:02J-024
77:02J-043
77:04A-036
77:07B-006
77:07B-012

Soil Treatment
77:02G-046
77:03F-111

Soil Types
77:02G-035
77:02G-126
77:03F-111
77:05B-010

Soil Water
77:02C-001
77:02D-003
77:02D-004
77:02D-005
77:02D-009
77:02E-002
77:02F-031
77:02F-032
77:02F-033
77:02G-001
77:02G-002
77:02G-003
77:02G-004
77:02G-005
77:02G-006
77:02G-007
77:02G-010
77:02G-014
77:02G-016
77:02G-017
77:02G-018
77:02G-019
77:02G-020
77:02G-022
77:02G-028
77:02G-030
77:02G-032
77:02G-033
77:02G-034
77:02G-035
77:02G-041
77:02G-043
77:02G-046
77:02G-047
77:02G-048
77:02G-054
77:02G-055
77:02G-056
77:02G-058
77:02G-060
77:02G-061
77:02G-074
77:02G-078
77:02G-081
77:02G-082
77:02G-087
77:02G-088
77:02G-091
77:02G-093
77:02G-094
77:02G-095
77:02G-096
77:02G-114
77:02G-115
77:02G-124
77:02G-128
77:02G-129
77:02G-136
77:02G-137
77:02G-138
77:02G-139
77:02G-140
77:02G-143
77:02G-146
77:02G-148
77:02G-151
77:02G-152
77:02G-156
77:02G-168
77:02G-174
77:02G-175
77:02I-002
77:02I-003
77:02I-005
77:02I-007
77:02I-008
77:02I-014
77:02I-015
77:02K-001
77:03B-001
77:03C-002
77:03F-004
77:03F-010
77:03F-011
77:03F-020
77:03F-034
77:03F-035
77:03F-036
77:03F-042
77:03F-044
77:03F-046
77:03F-050
77:03F-054
77:03F-067
77:03F-069
77:03F-075
77:03F-078
77:03F-082
77:03F-090
77:03F-099
77:03F-109
77:03F-112
77:03F-132
77:04A-003
77:04A-023
77:04A-025
77:04A-026
77:04A-029
77:04A-040
77:04B-002
77:05B-002
77:05B-035
77:05B-041
77:05B-050
77:05C-004
77:05C-005
77:07B-006
77:07B-015
77:07B-023
77:07B-036
77:07C-002

Soil Water Movement
77:02B-002
77:02D-003
77:02D-004
77:02D-009
77:02F-033
77:02G-002
77:02G-003
77:02G-004
77:02G-006
77:02G-009
77:02G-010
77:02G-014
77:02G-017
77:02G-018
77:02G-019
77:02G-020
77:02G-021
77:02G-022
77:02G-023
77:02G-024
77:02G-025
77:02G-026
77:02G-027
77:02G-028
77:02G-029
77:02G-030
77:02G-031
77:02G-033
77:02G-035
77:02G-041
77:02G-043
77:02G-046
77:02G-048
77:02G-049
77:02G-054

Soil Water Movement
(cont.)
77:02G-055
77:02G-056
77:02G-060
77:02G-061
77:02G-068
77:02G-076
77:02G-078
77:02G-080
77:02G-087
77:02G-093
77:02G-094
77:02G-115
77:02G-116
77:02G-124
77:02G-126
77:02G-128
77:02G-137
77:02G-138
77:02G-139
77:02G-140
77:02G-142
77:02G-143
77:02G-152
77:02G-174
77:02G-175
77:02I-002
77:02I-003
77:02I-008
77:03F-010
77:03F-011
77:03F-067
77:04A-023
77:04A-025
77:04A-026
77:05B-001
77:05B-002
77:05B-004
77:05B-024
77:05B-039
77:05B-050
77:07B-015
77:07C-002
77:08B-008

Soil-Water-Plant Relationships
77:02D-009
77:02D-011
77:02G-005
77:02G-008
77:02G-096
77:02I-002
77:02I-010
77:02I-011
77:02K-005
77:02L-001
77:03C-001
77:03F-004
77:03F-136

Soils
77:02B-001
77:02B-002
77:02C-001
77:02D-004
77:02F-033
77:02G-002
77:02G-003
77:02G-010
77:02G-011
77:02G-017
77:02G-018
77:02G-021
77:02G-022
77:02G-023
77:02G-024
77:02G-026
77:02G-027
77:02G-028
77:02G-029
77:02G-030
77:02G-031
77:02G-034
77:02G-035
77:02G-036
77:02G-037
77:02G-038
77:02G-039
77:02G-040
77:02G-041
77:02G-043
77:02G-050
77:02G-051
77:02G-052
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77:02G-054
77:02G-056
77:02G-057
77:02G-058
77:02G-059
77:02G-060
77:02G-062
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77:02G-108
77:02G-109
77:02G-110
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77:02G-112
77:02G-113
77:02G-114
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77:02G-130
77:02G-131
77:02G-133
77:02G-134
77:02G-135
77:02G-136
77:02G-140
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77:02G-146
77:02G-147
77:02G-148
77:02G-149
77:02G-150
77:02G-151
77:02G-152
77:02G-154
77:02G-155
77:02G-158
77:02G-159
77:02G-173
77:02G-174
77:02G-176
77:02J-010
77:02J-024
77:02J-043
77:02J-044
77:02K-003
77:03F-012
77:03F-022
77:03F-031
77:03F-041
77:03F-080
77:03F-081
77:03F-099
77:03F-100
77:03F-103
77:03F-128
77:03F-132
77:04A-031
77:04A-036
77:04B-014
77:04D-005
77:05A-004
77:05B-001
77:05B-002
77:05B-015
77:05B-032
77:05B-039
77:05B-042
77:05B-043
77:05B-045
77:05B-052
77:05C-004
77:05D-004
77:05G-026
77:05G-035
77:05G-036
77:05G-037
77:06A-006
77:07B-006
77:07B-008
77:07B-012
77:07B-016
77:07B-017
77:07B-019
77:07B-037

Solar Radiation
77:02D-002
77:03F-070
77:03F-084
77:03F-106
77:03F-107
77:03F-118

Solid Wastes
77:05D-009

Solubility
77:02K-002
77:05B-023

Solutes
77:02G-010
77:02G-018
77:02G-021
77:02G-022
77:02G-077
77:02G-124
77:02G-143
77:02G-175
77:05B-004
77:05B-016

Solutions
77:02G-004

Solvents
77:02G-001
77:05B-002

Sorghum
77:02G-104
77:03F-022
77:03F-040

Sorption
77:02G-012
77:02G-013
77:02G-022
77:02G-029
77:02G-088
77:02G-098
77:02G-106
77:04B-014

South Carolina
77:02G-054
77:05B-007

South Dakota
77:02G-125
77:02I-016

Soybeans
77:02G-046
77:02G-105
77:02I-001
77:03F-047
77:03F-071
77:03F-087

Spatial Distribution
77:02F-049
77:02G-017
77:02G-018

Specific Conductivity
77:05A-006
77:05A-007

Specifications
77:05A-001

Spectrophotometry
77:02D-002

Spraying
77:03B-001

Sprays
77:05B-006

Spring Water
77:02F-030

Springs
77:02F-030

Sprinkler Irrigation
77:02D-010
77:02F-027
77:02G-037
77:02G-058
77:02G-123
77:02I-016
77:03F-023
77:03F-056
77:03F-059
77:03F-060
77:03F-065
77:03F-076
77:03F-079
77:03F-081
77:03F-083
77:03F-086
77:03F-098
77:03F-103
77:03F-134
77:04A-004
77:04A-007
77:04A-020
77:04A-028
77:04A-031
77:04A-032
77:04A-033
77:04A-036
77:04A-039
77:04B-015
77:05B-003
77:05B-010
77:05B-042
77:05G-005
77:06C-001
77:06D-001
77:08B-006

Sprinklers
77:03F-059
77:03F-134
77:04A-032

Stability
77:02F-007

Stagnant Water
77:02G-077

Standards
77:05D-003
77:05G-018

State Government
77:06E-013

Statistical Methods
77:03F-005

Steady Flow
77:02F-009
77:02F-010
77:04A-023

Stomata
77:02I-010
77:02I-011

Storage
77:02F-001
77:05B-022

Storage Capacity
77:02G-095

Storage Coefficient
77:02F-006
77:02F-017
77:02F-022
77:02F-037
77:04B-007

Storm Runoff
77:02E-004
77:05B-005

Storm Water
77:05B-026

Storms
77:02E-004
77:02G-095

Stratification
77:02F-015

Stream Erosion
77:02J-043

Stream Gages
77:07B-005

Streamflow
77:02E-006
77:02G-025
77:02J-002
77:02J-003
77:03B-001

Streamflow Forecasting
77:02E-006

Streams
77:02F-046
77:02G-025

Streams
(cont.)
77:02J-001
77:02J-002
77:02J-013
77:04A-001
77:04B-003
77:04B-012
77:05B-053
77:05D-003

Stress
77:02F-006
77:03C-001
77:04B-012

Subsidization
77:03F-135

Subsoils
77:02G-173
77:03F-033

Subsurface Drainage
77:02F-032
77:02F-045
77:02G-060
77:04D-003

Subsurface Flow
77:02F-003
77:02F-012
77:02F-033
77:02G-018

Subsurface Irrigation
77:02G-026
77:02G-037
77:02G-061
77:02G-141
77:03F-023
77:03F-029
77:03F-127
77:04A-004
77:04A-025

Subsurface Runoff
77:05A-003

Subsurface Waters
77:02G-025

Suburban Areas
77:05B-031

Sugar Beets
77:02G-157
77:02I-012
77:03F-019
77:03F-112
77:03F-115
77:05B-035
77:07B-014

Sugarcane
77:03F-033
77:03F-064
77:05B-009

Sulfates
77:02F-016

Sulfur
77:02G-085
77:02G-099
77:02G-158
77:03F-015
77:03F-016

Sulfuric Acid
77:02G-154
77:05B-040

Summer
77:03B-001

Supplemental Irrigation
77:03F-101

Surface Drainage
77:02G-117
77:04D-005
77:05G-002

Surface Irrigation
77:02I-016
77:02J-010
77:02J-037
77:03F-002
77:03F-087
77:03F-097
77:04A-003
77:04A-008
77:04A-017
77:04A-018
77:04A-019
77:04A-020
77:04A-026
77:04A-029
77:04A-030
77:04A-038
77:04A-042
77:05B-042
77:05G-010
77:06D-001

Surface Runoff
77:02G-127
77:04A-042
77:04D-003
77:05A-003
77:05G-002

Surface Tension
77:08B-011

Surface Waters
77:03F-030
77:04A-001
77:04B-003
77:05B-051

Surfaces
77:05D-005

Surveys
77:02F-021

Suspended Particles
77:05B-051

Suspended Sediments
77:02J-014

Suspended Solids
77:02J-044
77:03F-030
77:04A-028
77:05B-026
77:05D-007
77:05G-010

Swelling Soil
77:02G-176

Systems Analysis
77:03F-001
77:03F-002
77:03F-005
77:03F-018
77:03F-088
77:04B-001
77:04B-002
77:04B-003
77:04B-006
77:04B-008
77:04B-012
77:05D-003
77:05G-018

Tailwater
77:02J-010
77:04A-020
77:05B-037
77:08B-001

Technology
77:03F-018
77:03F-027
77:04A-042
77:05G-013
77:05G-022
77:06A-001

Temperature
77:02C-001
77:02D-008
77:02F-007
77:02F-034
77:02G-091
77:02G-140
77:02I-018
77:02L-001
77:03F-038
77:03F-040
77:03F-054
77:03F-055
77:03F-058
77:05B-022
77:05B-035
77:05B-053
77:07B-032
77:07B-036

Tennessee
77:02G-032

Tensiometers
77:02D-004
77:02G-001
77:02G-008
77:02G-016
77:02G-030
77:02G-065
77:02G-176
77:02I-016
77:03F-010
77:03F-011
77:03F-023
77:03F-042
77:03F-075
77:04D-001

Terracing
77:02J-033
77:08B-009

Tertiary Treatment
77:05D-005

Test Wells
77:02F-901
77:05E-001
77:08B-004

Testing
77:02G-174
77:02J-011

Testing Procedures
77:02G-174
77:02J-011
77:04D-005
77:05A-010

Texas
77:02F-043
77:02G-014
77:04A-004

Theis Equation
77:02F-006
77:04B-007

Theoretical Analysis
77:02D-001
77:02F-006
77:02F-012
77:02F-013
77:02F-014
77:02G-021
77:02G-033
77:02G-125
77:02J-042
77:08B-016

Thermal Conductivity
77:02G-006

Thermal Pollution
77:05B-007
77:05B-022
77:05G-015

Thermal Power
77:04A-041

Thermal Properties
77:02G-005

Thermal Water
77:02F-007

Thermodynamics
77:02G-112

Tile Drainage
77:02F-032
77:02F-045
77:04D-003
77:04D-005
77:05A-003

Tiles
77:04B-002

Tillage
77:03F-128

Time
77:02B-001
77:02F-040
77:07B-030

Time Lag
77:04B-007

Timing
77:07B-030

Tomatoes
77:02G-105
77:03F-004

Toxicity
77:07B-001

Trace Elements
77:02I-018
77:05A-006

Tracers
77:02G-018
77:02G-023
77:02G-024
77:02G-054
77:05B-002
77:07B-001
77:07B-029

Translocation
77:03F-006

Transmissivity
77:02F-017
77:02F-022
77:02F-037
77:02F-049
77:02F-051
77:04B-007
77:08B-004

Transpiration
77:02D-008
77:02D-010
77:02D-011
77:02I-005
77:02L-001
77:03B-001

Transpiration Control
77:02D-002
77:03B-001

Transfer
77:02G-021
77:02G-077

Trap Efficiency
77:05G-031

Travel Time
77:05B-016

Treatment Facilities
77:05E-002

Trickle Filters
77:05G-035

Tritium
77:02G-012
77:02G-018
77:02G-054

Turbidity
77:05B-018
77:07B-013

Turbulence
77:04D-007
77:07B-022

Turbulent Flow
77:07B-022
77:08B-001

Turf
77:02G-167
77:03F-076
77:03F-081
77:03F-100
77:03F-104

Turf Grasses
77:03F-081
77:03F-100

Underflow
77:02F-015

Underground Storage
77:05B-022
77:05E-001

Underseepage
77:02F-015

Uniform Flow
77:08B-012

Uniformity
77:03F-028
77:04A-034

Uniformity Coefficient
77:03F-028
77:08B-012

Unsaturated Flow
77:02F-014
77:02F-030
77:02G-003
77:02G-009
77:02G-012
77:02G-013
77:02G-020
77:02G-022
77:02G-024
77:02G-026
77:02G-031
77:02G-033
77:02G-049
77:02G-054
77:02G-060
77:02G-077
77:02G-081
77:02G-094
77:02G-128
77:02G-137
77:04A-025
77:05D-004

Unsteady Flow
77:02F-009
77:02F-047
77:02F-048
77:02G-125

Urban Runoff
77:02G-095
77:05B-026

Urbanization
77:02F-043
77:02G-095
77:02J-013
77:02J-035
77:03F-026
77:03F-053
77:05B-031
77:08C-001

Ureas
77:02B-001
77:02G-062
77:02G-097
77:02G-160
77:02G-163
77:03F-127

Use Rate
77:05G-039

Utah
77:02G-078
77:04A-002
77:05B-003
77:05G-018
77:05G-028

Vapor Pressure
77:02G-007

Variability
77:02G-017
77:02G-018
77:03F-001
77:05B-012
77:05B-020

Vegetables
77:02G-102

Vegetation
77:02D-007
77:02E-005
77:02G-034
77:02J-032
77:02J-039

Vegetation Effects
77:02G-034
77:02J-007
77:02J-032
77:02J-039

Velocity
77:02F-034
77:02J-040
77:04A-028
77:04D-007
77:07B-022
77:07B-028
77:08B-005

Vertical Migration
77:02G-029

Viscosity
77:08B-011

Voids
77:02C-001

Vortices
77:04D-007

Washington
77:02G-082
77:03F-012
77:03F-085
77:05A-004
77:05G-011
77:05G-012

Waste Disposal
77:05D-004
77:05D-007
77:05D-008
77:05E-001

Waste Water
77:04B-014
77:05D-006
77:06A-002

Waste Water Disposal
77:04B-011
77:05B-005
77:05B-045
77:05D-004
77:05E-001
77:05E-002

Waste Water Management
77:03F-007

Waste Water Pollution
77:05D-009

Waste Water Treatment
77:05A-009
77:05A-010
77:05B-026
77:05D-002
77:05D-003
77:05D-005
77:05D-006
77:05D-007
77:05E-002
77:06A-003

Wastes
77:05B-045

Water
77:02K-002
77:03F-073
77:03F-074
77:03F-077
77:03F-093
77:05G-020
77:05G-025
77:06A-002
77:06D-001
77:06E-009
77:07B-001

Water Allocation (Policy)
77:03F-018
77:03F-061
77:03F-088
77:04B-008
77:05G-003
77:06A-006
77:06E-010
77:06E-011

Water Analysis
77:05B-006
77:05B-048
77:07B-004

Water Balance
77:02G-010
77:02G-025
77:04A-039
77:04B-002

Water Chemistry
77:02F-016
77:02F-030
77:02F-049
77:05A-009
77:05B-031
77:05B-048
77:05G-004
77:05G-015
77:05G-033
77:07B-001
77:07B-004
77:07B-005

Water Circulation
77:02D-008

Water Control
77:04A-039

Water Conservation
77:02D-011
77:02F-027
77:03F-009
77:03F-025
77:03F-048
77:03F-066
77:03F-067
77:03F-072
77:03F-076
77:03F-077
77:03F-081
77:03F-091
77:03F-093
77:03F-097
77:03F-101
77:03F-103
77:03F-105
77:03F-114
77:03F-115
77:03F-117
77:03F-120
77:03F-121
77:03F-122
77:03F-136
77:04A-020
77:04A-021
77:05B-044
77:05D-009
77:05G-022

Water Consumption
77:06A-006

Water Costs
77:06E-010

Water Delivery
77:03F-005
77:03F-072
77:03F-088
77:03F-089

Water Demand
77:03F-002
77:03F-073
77:03F-074
77:04B-001
77:05G-018
77:06E-001

Water Distribution (Policy)
77:03F-001

Water Districts
77:05G-003

Water Law
77:05G-022
77:06A-004
77:06A-005
77:06E-004
77:06E-007
77:06E-009
77:06E-011
77:06E-014

Water Levels
77:02F-011
77:02F-019
77:02F-020
77:02F-025
77:02F-037
77:02F-046
77:02G-125
77:02G-128
77:04B-007
77:05B-045
77:08B-009

Water Level Fluctuations
77:02F-013
77:02F-020

Water Loss
77:02D-003

Water Management (Applied)
77:02G-096
77:03C-002
77:03F-005
77:03F-007
77:03F-090
77:03F-135
77:04A-009
77:04B-001
77:05A-004
77:05B-010
77:05B-046
77:05G-005
77:05G-023
77:05G-034
77:06B-002

Water Measurement
77:04A-011
77:04A-039
77:05A-001
77:07B-024
77:07B-025
77:07B-027
77:07B-028
77:07B-029

Water Policy
77:03F-135
77:05G-018

Water Pollution
77:02E-004
77:02F-050
77:02J-022
77:03F-007
77:03F-025
77:04D-001
77:05A-006
77:05B-001
77:05B-006
77:05B-007
77:05B-009
77:05B-010
77:05B-016
77:05B-019
77:05B-020
77:05B-021
77:05B-027
77:05B-031
77:05B-034
77:05B-045
77:05B-046
77:05B-049
77:05B-056
77:05C-005
77:05D-006
77:05D-008
77:05D-009
77:05G-002
77:05G-015
77:05G-031
77:05G-038
77:06A-004
77:06E-004
77:06E-008
77:07B-004
77:07B-005

Water Pollution Control
77:02E-004
77:03F-025
77:03F-057
77:05G-021
77:05G-023
77:06A-004
77:07B-004

Water Pollution Effects
77:03F-057

Water Pollution Sources
77:03F-057
77:05B-004
77:05B-005
77:05B-006
77:05B-007
77:05B-016
77:05B-019
77:05B-023
77:05B-024
77:05B-025
77:05B-048
77:05B-049
77:05G-004
77:05G-017

Water Pressure
77:04B-015

Water Properties
77:08B-001

Water Quality
77:02E-003
77:02E-004
77:02F-041
77:02F-049
77:02F-050
77:02G-010
77:02G-044
77:02G-078
77:02G-103
77:02J-011
77:02J-018
77:02J-022
77:02J-025
77:02J-026
77:02J-031
77:02J-036
77:02J-045
77:03F-024
77:03F-025

Water Quality
(cont.)
77:03F-051
77:03F-052
77:03F-062
77:03F-066
77:03F-120
77:04A-003
77:04A-009
77:04A-020
77:04D-002
77:05A-004
77:05A-006
77:05A-007
77:05A-008
77:05B-005
77:05B-006
77:05B-007
77:05B-009
77:05B-012
77:05B-017
77:05B-020
77:05B-021
77:05B-027
77:05B-030
77:05B-031
77:05B-034
77:05B-037
77:05B-040
77:05B-041
77:05B-046
77:05B-048
77:05B-049
77:05B-053
77:05C-001
77:05C-002
77:05C-003
77:05D-004
77:05D-006
77:05G-001
77:05G-004
77:05G-008
77:05G-009
77:05G-011
77:05G-012
77:05G-014
77:05G-016
77:05G-019
77:05G-020
77:05G-025
77:05G-027
77:05G-028
77:05G-030
77:05G-033
77:05G-038
77:06A-001
77:06A-002
77:06A-003
77:06A-006
77:06E-002
77:06E-003
77:06E-004
77:06E-005
77:06E-008
77:07B-017
77:07B-018
77:04A-001
77:04B-013
77:05A-008
77:05B-012
77:05B-037
77:05D-003
77:05D-006
77:05E-001
77:05G-003
77:05G-008
77:05G-010
77:05G-014
77:05G-016
77:05G-018
77:05G-022
77:05G-038
77:06A-001
77:06A-003
77:06E-002
77:06E-003
77:06E-004
77:06E-005
77:06E-008
77:07B-004
77:07B-018

Water Quality Control
77:03F-007
77:03F-024
77:03F-066

Water Quality Management
77:03F-025
77:04D-002

Water Quality Standards
77:06E-009

Water Rates
77:03F-135

Water Requirements
77:02D-007
77:02I-001
77:04B-003

Water Resources
77:02D-007
77:02E-006
77:02G-034
77:02J-026
77:03F-072
77:03F-076
77:03F-093
77:04A-020
77:04A-022
77:05G-015
77:05G-016
77:05G-022
77:06A-004
77:06A-005
77:06E-004
77:06E-009
77:06E-010
77:06E-011

Water Resources Development
77:04B-001
77:06A-004
77:06A-005
77:06B-001
77:06B-002

Water Reuse
77:04B-015
77:05D-001

Water Rights
77:05G-003
77:06E-005
77:06E-006
77:06E-014

Water Retention
77:02G-176

Water Sampling
77:05B-020
77:07B-002
77:07B-005

Water Shortage
77:03F-018
77:04A-020

Water Storage
77:02G-065
77:04A-022

Water Supply
77:03F-003
77:03F-005
77:03F-018
77:03F-072
77:03F-093
77:04A-020
77:04A-022
77:04B-001
77:04B-003
77:04B-008
77:05B-020
77:06A-006
77:06E-011

Water Supply Development
77:03F-093

Water Table
77:02D-007
77:02F-001
77:02F-004
77:02F-008
77:02F-009
77:02F-011
77:02F-018
77:02F-019
77:02F-032
77:02F-045
77:02G-025
77:02G-048
77:02G-125
77:02G-126
77:03F-019
77:03F-037
77:03F-064
77:04A-025
77:04B-002
77:04B-004
77:04B-005
77:05B-045
77:05B-056
77:07B-002
77:07B-021

Water Temperature
77:02F-007
77:02F-034
77:03B-007

Water Use
77:05G-039

Water Users
77:02D-007

Water Utilization
77:02D-007
77:02G-096
77:02I-016
77:03F-004
77:04B-008

Water Vapor
77:02G-006
77:02G-007

Water Wells
77:02F-001
77:02F-019
77:02F-023
77:02F-047
77:02F-048
77:04B-007
77:04B-011
77:05A-007
77:05B-016
77:05B-020
77:05B-031

Water Yield
77:05G-003
77:08B-004

Watershed Management
77:04D-002
77:05B-033
77:05G-002
77:07B-009

Watersheds
77:02E-003
77:02G-093
77:04D-002
77:05B-033
77:05G-023
77:06A-005

Watersheds (Basins)
77:02D-001
77:02E-004
77:02E-005
77:02G-014
77:02G-127
77:02G-142
77:02J-013
77:02J-041
77:02J-042
77:02J-046
77:03B-001
77:03F-024
77:04D-003
77:04D-006
77:05B-027
77:05G-026
77:07B-009

Waves (Water)
77:08B-001

Weather Data
77:02D-001
77:04B-002

Weed Control
77:03F-087
77:03F-133
77:05G-002

Weirs
77:04A-011
77:07B-024
77:07B-025
77:07B-027
77:08B-005
77:08B-011
77:08B-016

Well Screens
77:02F-019

Well Spacing
77:08B-004

Wellpoints
77:07B-002

Wells
77:02F-017
77:02F-019
77:02G-025
77:04A-001
77:04B-001
77:04B-004
77:04B-006
77:04B-011
77:05A-007
77:05B-016
77:05B-018
77:05B-022
77:05B-031

Wetting
77:02G-011
77:02G-035
77:02G-056
77:02G-058
77:02G-074

Wheat
77:02G-005
77:02G-156
77:02G-161
77:02G-162
77:02G-166
77:02I-002
77:03F-032
77:03F-034
77:03F-035
77:03F-036
77:03F-043
77:03F-054

Wildlife
77:02G-073
77:03F-119

Wildlife Conservation
77:02G-073

Wildlife Habitats
77:02G-073
77:03F-119

Wildlife Management
77:03F-119

Wind Velocity
77:02D-006
77:02G-007
77:03F-034
77:03F-035
77:09C-001

Windbreaks
77:03F-034
77:03F-035

Winds
77:02D-006

Wisconsin
77:03F-045
77:03F-056
77:04B-005
77:05B-017

Withdrawal
77:02D-005
77:02F-011
77:04B-005

Wyoming
77:03F-077

Zinc
77:02G-086
77:02G-169
77:03F-032
77:05A-006